

Docket No.: 04303/100N160-US2
(PATENT)

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Patent Application of:
Chakki Kavoori, et al.

Application No.: 10/750,532

Confirmation No.: 5596

Filed: December 30, 2003

Art Unit: 2122

For: METHOD AND APPARATUS FOR
SOFTWARE-BASED ALLOCATION AND
SCHEDULING OF HARDWARE RESOURCES
IN AN ELECTRONIC DEVICE

Examiner: Not Yet Assigned

PETITION PURSUANT TO 37 C.F.R. §1.47(a)

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Dear Sir:

This is a petition pursuant to 37. C.F.R. §1.47(a) to have this patent application made by Chakki Kavoori and Keith Reiken on behalf of themselves and David M. Holmes (non-signing inventor). This petition accompanies a Declaration signed by Chakki Kavoori and Keith Reiken.

Mr. Holmes refuses to execute the Declaration. Upon information and belief, the pertinent facts are as follows.

On May 4, 2004, the office of the undersigned forwarded a copy of the present patent application including the drawings, and Declaration and Power of Attorney for execution by Mr. Holmes. (Exhibit A)

On June 11, 2004, the office of the undersigned forwarded a second Declaration and Power of Attorney for execution by Mr. Holmes. (Exhibit B) This new Declaration and Power of

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12/03/2004 WABDELRI 00000042 040100 10750532
01 FC:1463 70.00 DA 130.00 OP

12/02/2004 WABDELRI 00000055 10750532
04 FC:1464 130.00 OP
Adjustment date: 12/03/2004 WABDELRI 130.00 OP
04 FC:1464
12/02/2004 WABDELRI 00000055 10750532

Attorney was sent because the first Declaration and Power of Attorney was not the version required by the Assignee, Infineon Technologies AG.

On July 1, 2004, the office of the undersigned forwarded a third Declaration and Power of Attorney for execution by Mr. Holmes. (Exhibit C) This new Declaration and Power of Attorney was sent because the other Declaration and Power of Attorneys were no longer acceptable by the U.S. Patent Office due to a rule change.

Mr. Holmes did not return an executed copy of any of the three Declarations and Power of Attorney.

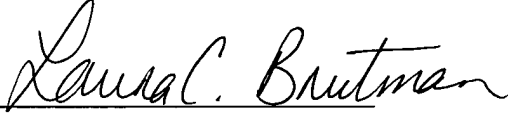
On November 2, 2004, Heather Rowland, an employee of a subsidiary of Infineon Technologies North America Corp., which is a subsidiary of the assignee, Infineon Technologies AG, sent Mr. Holmes an e-mail requesting his home address. As indicated in Ms. Rowland's e-mail to the office of the undersigned, Mr. Holmes responded by stating that he was not willing to take the time to read the application or sign any documents. (Exhibit D)

The last known address of Mr. Holmes is 21696 Noonan Court, Cupertino, CA 95014.

From the preceding explanation, it will be appreciated that despite its best efforts, the office of the undersigned has been unable to obtain Mr. Holmes' signature on a Declaration for the present patent application. Accordingly, it is respectfully requested that the U.S. Patent Office grant this petition and permit this application to be made by Chakki Kavoori and Keith Reiken on behalf of themselves and David M. Holmes, the non-signing inventor.

A check for the fee set forth in 37 C.F.R. §1.17(h) in the amount of \$130.00 is enclosed.
The Commissioner is authorized to charge any deficiency or credit any excess in this fee to Deposit
Account No. 04-0100.

Respectfully submitted,

By 

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May 4, 2004

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Reference: 04303/100N160-US2

David M. Holmes
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Re: U.S. Patent Application Serial No. 10/750,532
For: METHOD AND APPARATUS FOR SOFTWARE-BASED
ALLOCATION AND SCHEDULING OF HARDWARE RESOURCES IN
AN ELECTRONIC DEVICE
Filed: December 30, 2003
Your Ref.: 2003P93061 US02

Dear Mr. Holmes:

In accordance with instructions received from Infineon Technologies North America Corp. we enclose a copy of the patent application as filed on December 30, 2003.

Please review the enclosed Declaration and Assignment documents carefully and sign where indicated. If minor changes need to be made to correct for, *e.g.*, typographical errors, they can be made in pen. However, all such changes must be *initialed and dated*.

Please make sure that you have read the application, including its claims, before you sign any of the documents. Please contact us if you identify any corrections that need to be made in the application.

Please read the Inventors' Declaration and Power of Attorney carefully, paying particular attention to the fact that by executing the Declaration, you acknowledge the following:

- (a) to the best of his/her knowledge, the named inventors are the first and true inventors of the subject matter claimed in the patent application;
- (b) to the best of his/her knowledge, the invention described in this application was not known or used by others in this country nor patented nor published by others anywhere in the world before this invention was made;
- (c) this invention has not been patented nor published more than one year prior to the filing date of the present application;
- (d) the invention was not publicly used nor sold nor offered for sale more than one year prior to the filing date of the present application;

(e) no foreign patent application has been filed for this invention (except as set forth in the declaration); and

(f) as an inventor, he/she owes the highest duty of candor and good faith in his dealings with the Patent and Trademark Office, and, in discharge of this duty, must disclose to the Patent and Trademark Office any information of which he/she is aware that is "material to examination of this application." Such information is material when there is a "substantial likelihood" that a Patent Examiner would consider it important in deciding whether the subject matter of the present application is patentable. Please give your attention to the attachment entitled "Duty to Disclose Information" and confirm that all known information which is material to the examination of this application has been disclosed to us.

Please read the attachment entitled "Duty to Disclose Information" and to confirm that all known information which is material to the examination of this application has been disclosed to us.

Please return the executed documents to us for filing with the Patent and Trademark Office. If you have any questions or comments, please do not hesitate to contact me.

Sincerely,



Flynn Barrison

FB:ih

cc: Laura C. Brutman, Esq.

DUTY TO DISCLOSE INFORMATION

Please bring all currently known information to our attention as soon as possible.

METHOD AND APPARATUS FOR SOFTWARE-BASED ALLOCATION AND SCHEDULING OF HARDWARE RESOURCES IN AN ELECTRONIC DEVICE

CROSS-REFERENCE TO RELATED APPLICATIONS

This application claims priority to the provisional patent application with the
5 following Serial Number: 60/222,853, filed on August 3, 2000, the specification of which is
hereby incorporated by reference in its entirety.

Related applications, which are incorporated herein by reference, are:

“Improved Apparatus and Method for Multi-Threaded Signal Processing,” Serial No.
09/492,634, filed on January 27, 2000;

10 “Method and Apparatus for Time-Sliced and Multi-Threaded Data Processing in a
Communication System,” Serial No. 60/222,007, filed on July 31, 2000; and

“Method and Apparatus for Software-Based Allocation and Scheduling of Hardware
Resources in an Electronic Device,” Serial No. 60/223,062, filed on August 3, 2000.

TECHNICAL FIELD

15 The present claimed invention relates to the field of electronic devices. In particular,
the present claimed invention relates to an apparatus and a method for managing hardware
resources in an electronic device.

BACKGROUND OF THE INVENTION

Electronic communication devices contain a wide range of hardware resources to
20 provide the different signal processing functions necessary to transmit and receive data
signals. However, the discrete hardware resources by themselves do not coordinate input

data, output data, enabling signals, etc. amongst the wide ranges of hardware resources. Consequently, a need arises for a controller to provide coordination between the wide range of hardware resources in an electronic communication device. Furthermore, the controller should be real time to accommodate a continual real-time flow of input data into the communication device and the resultant processed output data.

One method of controlling the hardware resources is to utilize a hardware-based controller that is designed for the specific application. However, a hardware-based controller can be very inflexible beyond its specific application. In contrast, wireless communication applications continue to proliferate to include such different systems as: fixed wireless, unlicensed Federal Communications Commission (FCC) wireless, local area network (LAN), cordless telephony, personal base station, telemetry, mobile wireless, encryption, and other digital data processing applications. While each of these applications utilizes spread spectrum communications, they generally utilize unique and sometimes incompatible data processing methodologies. Furthermore, new spread spectrum applications will continue to arise while existing spread spectrum applications continue to mature and evolve over time. These observations mean that existing and new spread spectrum applications will frequently use unique and apparently incompatible hardware and software resources, along with different methods of coordinating and operating them.

However, if a communication device implements a controller as an application specific integrated circuit (ASIC), then it can have limited flexibility. For example, if an ASIC controller is designed for a specific number of hardware resources in an electronic device and a specific operating scenario or usage rate of these hardware resources, then it may be difficult to implement the ASIC controller for a different application or operating environment. One solution is to design and implement a new ASIC device for different applications. But this practice of proliferating control devices to accommodate systems with

varied standards and protocols can be costly in terms of design, testing, manufacturing, and infrastructure resources. Resultantly, a need arises for a method and apparatus of controlling hardware resources that overcomes the limited flexibility of an ASIC controller in order to accommodate the variation in spread spectrum communication systems.

5 Besides the application-specific limitation of an ASIC controller, the ASIC controller can have limited flexibility to accommodate performance failures in a system. For example, a controller can be designed to accommodate a very rigid set of performance criteria and protocol status. If even a single hardware resource, which comprises only a small fraction of the overall system, fails, then the overall system may fail because the controller may not be
10 designed to accommodate failure modes. However, this paradigm is wasteful, especially when a very large percentage of the system is fully operational. Furthermore, this paradigm can be inconvenient to remedy as it may require replacement of chips, boards, or higher assembly parts that contain the failed part.

 If a controller is designed as a sequential controller, then it can sequentially start and
15 stop a series of hardware resources. After the controller receives a completion signal from a first hardware resource, the controller can then initiate a subsequent hardware resource. Unfortunately, this process can result in a system effect referred to as fragmenting. If hardware resources are left idle while a controller waits for an active hardware resource to complete its operation and send its completion signal to the controller, then the idle hardware
20 does not contribute to the processing efficiency of the overall device. Thus, it is possible that fragmentation will decrease data throughput, while increasing propagation delay for the electronic device. As a result, a need arises for a controller that can overcome the effects of fragmenting the hardware resources that it controls.

 An additional situation encountered in real-time operation of an electronic
25 communication device is the frequent change in the device's operating environment or

processing needs. For example, a wireless communication system has frequent changes in the number of users (calls are initiated and terminated) and the quality and quantity of signals (e.g., the multipaths signal to noise ratio and strength, quantity of data transmitted, type of data transmitted, etc.). In short, a communication system can be extremely dynamic in many aspects. If an ASIC controller is utilized, its ability to accommodate the changes in the system may be limited to those conceived of during the design of the hardware-based controller. Consequently, its ability to accommodate new variations in system dynamics can be limited. The performance of a controller can also be compromised by inefficient use of hardware resources in the dynamic environment, by system interruptions, system crashes, and compounded fragmenting due to the dynamically changing environment. Thus, a need arises for a controller that can overcome the limitations of, system interruptions, system crashes, compounded fragmenting, and inefficient use of hardware resources due to the dynamically changing environment and other factors. Furthermore, a need arises for a controller that can effectively accommodate the changes in the system without compromising the integrity of the system itself, including processes that have not changed.

However, given their complexity, quantity, and interactive requirements of hardware resources in an electronic device, it would be very difficult to manually and discretely control them individually. And to manually implement changes to the controller of hardware resources would be even more difficult because of possible conflicts and lack of debugging.

In short, a user of an electronic device may desire to control the hardware resources and have flexibility in their control, but the user doesn't want the associated difficulty and complications of programming the individual devices themselves. Consequently, a need arises for a method and apparatus of controlling hardware resources that provides user with control and flexibility without the associated complexities and problems.

As with most electronic devices, power consumption can have detrimental effects such as generating heat, affecting lifespan, and consuming limited power resources such as batteries. The aforementioned issues involving flexibility, fragmenting, system compromises, etc. are typically detrimental to the power consumption of the electronic device.

5 Consequently, a need arises for a controller that can overcome the limitations of inefficient management of hardware resources in terms of power consumption. The aforementioned limitations are generally applicable to all electronic devices.

SUMMARY OF THE INVENTION

The present invention provides a method and apparatus that coordinates, via allocation
10 and scheduling, a wide range of hardware resources in an electronic communication device in a real time manner to accommodate a continual real-time flow of input data into the communication device and the resultant processed output data. Additionally, the present invention overcomes the limited flexibility of an ASIC controller in order to accommodate the variation in hardware resources and uses for the wide range of spread spectrum
15 communication systems. The present invention also overcomes the effects of fragmenting hardware resources and the inefficient use of hardware resources, system interruptions and system crashes, and compounded fragmenting due to the dynamically changing environment. Also the present invention accommodates a dynamically changing environment without compromising the integrity of the system for processes that have not changed. And the
20 present invention provides a method and apparatus of controlling hardware resources that provides user control and flexibility without the associated complexities and problems. Finally, the present invention overcomes the limitations of inefficient management of hardware resources in terms of power consumption.

A first embodiment of the present invention provides a method of controlling hardware resources in a communication device having a processor, a computer readable memory, and at least one hardware resource. The method begins with a first step of locating a memory address in the computer readable memory that has operating information for a first hardware resource. The memory address stores information such as semi-static hardware control parameters (flags, parameters, states, or configurations) and dynamic hardware control parameters for operating the hardware resources. In the next step, operating information located by the first memory address is communicated to the hardware resource. In the next step, a memory address, e.g., a pointer, linking the first address to a subsequent address containing information for operating a subsequent hardware resource, is read. By storing operating information of hardware in software and linking this information for multiple hardware resources via linking addresses, the present invention provides flexible resource allocation and scheduling of the hardware resources.

A second embodiment of the present invention provides a method of dynamically changing a controller function for a hardware resource in a communication device having a processor, a computer readable memory, and at least one hardware resource. In a first step, a list of linking addresses, viz. pointers, associated with the hardware resources is received at the communication device. Next, a list of hardware information, e.g., operating, controlling and configuring information, that is respectively associated with hardware resources is received at the communication device. In the next step, a second list of pointers is provided in the computer readable memory based on the first list of pointers. One of the lists of pointers is designated as the active list, with the other list of pointers is designated as the passive list. In the last step, the hardware information hardware resources in the communication device are operated according to the active list of pointers and the list of hardware information. Changes desired to the list of linking addresses are performed on the

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passive list of pointers while the active list continues to manage the hardware resources. At an appropriate time, the designation for both lists of linking address is instantaneously swapped and the list of linking addresses with the desired changes now operates the hardware resources.

5 These and other objects and advantages of the present invention will become apparent to those of ordinary skill in the art after having read the following detailed description of the preferred embodiments, which are also illustrated in the various drawing figures.

BRIEF DESCRIPTION OF THE DRAWINGS

10 The drawings included herewith are incorporated in and form a part of this specification. The drawings illustrate embodiments of the invention and, together with the description, serve to explain the principles of the invention. It should be understood that the drawings referred to in this description are not drawn to scale unless specifically noted as such.

15 Fig. 1A is a block diagram of an electronic communication device that uses software-based allocation and scheduling of hardware resources, in accordance with one embodiment of the present invention.

 Fig. 1B is a block diagram of the components of a tracking processor that uses software-based allocation and scheduling of hardware resources, in accordance with one embodiment of the present invention.

20 Fig. 1C is a graph of time showing multiple processing cycles within a given system cycle for the reuse a hardware resource, in accordance with one embodiment of the present invention.

Fig. 2A is a block diagram of a system for configuring the software-based allocation and scheduling of hardware resources in a communication device, in accordance with one embodiment of the present invention.

Fig. 2B is a block diagram of a computer used to generate code for software-based allocation and scheduling of hardware resources communication device, in accordance with one embodiment of the present invention.

Fig. 2C is a block diagram of a function that generates code for software-based allocation and scheduling of hardware resources, in accordance with one embodiment of the present invention.

Fig. 3A is a table of computer memory fields that store code for software-based allocation and scheduling of hardware resources, in accordance with one embodiment of the present invention.

Fig. 3B is a table of computer memory fields that allow dynamic changes in the software-based allocation and scheduling of hardware resources, in accordance with one embodiment of the present invention.

Fig. 3C is a table of computer memory fields that provide a hierarchy of software-based allocation and scheduling of hardware resources, in accordance with one embodiment of the present invention.

Fig. 3D is a table of computer memory fields that track users of software-based allocation and scheduling of hardware resources, in accordance with one embodiment of the present invention.

Fig. 4A is a flowchart of a process that operates a software-based allocator/scheduler of hardware resources in an electronic device, in accordance with one embodiment of the present invention.

utilized in wireless communications for many functions including, but not limited to: filtering, searching, modulation, demodulation, encoding, decoding, estimating, etc. The systems or techniques which utilize data processing include, but are not limited to, fixed wireless, unlicensed Federal Communications Commission (FCC) wireless systems, wireless local area network (W-LAN), cordless telephony, cellular telephony, personal base station, telemetry, and other digital data processing applications. The present invention can be applied to both transmitters, e.g., a base station, and to receivers, e.g., a terminal, for fixed wireless, W-LAN, cellular telephony, and personal base station applications.

In particular, the present invention is applicable to the following exemplary list of digital direct sequence spread spectrum communication applications. One fixed wireless application to which the present invention may be applied is a metropolitan multipoint distribution system (MMDS). Examples include wireless cable broadcast, or two-way wireless local loop (WLL) systems. Some examples of a W-LAN, that can communicate digitized audio and data packets, for which the present invention can be applied, include Open Air and the Institute of Electrical and Electronics Engineers (IEEE) specification 802.11b. In yet another application, a specific example of an unlicensed FCC application to which the present invention may be applied include the Industrial, Scientific, and Medical band (ISM) devices, which can include cordless telephony products. Personal base stations can utilize either cordless or cellular telephony wireless communication standards. Lastly, the cellular telephony systems in which the present invention can be applied includes, but is not limited to, IS-95, IS2000, ARIB, 3GPP-FDD, 3GPP-TDD, 3GPP2, 1EXTREME, or other user-defined protocols. The range of code sequences utilized in the exemplary spread spectrum applications disclosed herein, are useful to define the class of functions for which the present configurable code generator unit is applicable. The present invention can also be utilized in any electronic device needing to control hardware resources.

The detailed description of the present invention begins with a description of a spread-spectrum communication device, in Fig. 1A, that uses software-based allocation and scheduling of hardware resources. Next, the components of an exemplary processor, e.g., the tracking processor, that uses software-based allocation and scheduling of hardware resources is described in Fig. 1B. A description of the reuse of hardware resources in an electronic device to improve device efficiency is described through the timeline graph of Fig. 1C. The detailed description continues with a higher-level system, in Fig. 2A, for configuring the software-based allocation and scheduling of hardware resources in a communication device. A computer used to generate code for software-based allocation and scheduling of hardware resources in a communication device is described in Fig. 2B. The function implemented by the computer of Fig. 2B that generates code for software-based allocation and scheduling of hardware resources is then described in Fig. 2C. An exemplary table of computer memory fields that store code for software-based allocation and scheduling of hardware resources is described for Figs. 3A through 3D. Thereafter, multiple processes associated with the software-based allocation and scheduling of hardware resources in an electronic device are described in Fig. 4A through Fig. 4C. In particular, the processes for operating, generating code for, and dynamically changing the software-based allocation and scheduling of hardware resources in an electronic device are described therein.

COMMUNICATION DEVICE

Referring now to Fig. 1, a block diagram of an electronic communication device that uses software-based allocation and scheduling of hardware resources is shown in accordance with one embodiment of the present invention. Electronic communication device 100a provides an exemplary application of the present invention in a wireless direct sequence spread spectrum (DSSS) base transceiver station (BTS).

Communication device 100a includes a receiver processor 102, a transmit processor 106, a searcher processor 110, and a matched filter processor 111. Receiver processor 102 includes tracking scheduler 102a coupled to hardware resources 102b. Transmit processor 106 includes downlink scheduler 106a coupled to hardware resources 106b. Similarly, searcher processor 110 includes searcher scheduler 110a coupled to hardware resources 110b while matched filter processor 111 includes filter scheduler 111a coupled to hardware resources 111b. Each scheduler 102a, 106a, 110a and 111a provides respective a software-based scheduler/allocator of hardware resources 102b, 106b, 110b, and 111b. The details of the components and processes for software-based allocation and scheduling of hardware resources are described in more detail in subsequent hardware figures and flowchart figures.

Communication device 100a also includes an antenna 101, a front-end processing block 103, a base band processing block 116, a data processing block 119, a microprocessor 130, a memory block 120, and a bus 117. Front-end processing block 103 is coupled to base band processing block 116, both of which are coupled to microprocessor 130 and memory block 120 via bus 117. Microprocessor 130 and memory block 120 support the exchange of data, control, or status information between the various components of communication device 100a. Base band processor block 116 is coupled to front-end processing block 103 and is provided to receive signals while transmit processor block 106 is provided to transmit signals.

Front-end processing block is coupled to antenna 101 to receive a wireless signal. Front-end processing block includes components and functions known to those skilled in the art. Data processing block 119 performs functions such as decoding, etc., that are performed by a codec device, and other components known by those skilled in the art. These components are not shown in data processing block 119 for purposes of clarity.

Base band processing block 116 is operable to process the band of frequencies of the signal delivered by a source, e.g., via front end processing and antenna 101. Base band

processing block 116 includes a code generator unit (CGU) 104, a searcher processor block 110, a parameter estimator block 112 and a combiner block 108 all coupled to the receiver processor block 102. CGU 104, combiner(s) 108, and parameter estimator 112 have components and provide functions that are known by those skilled in the art. For example, receiver processor 102 performs despreading and demodulation functions known by those skilled in the art, while searcher processor 110 provides searching and filtering functions known to those skilled to locate signals. Transmit processor 106 performs modulation functions known by those skilled in the art. Matched filter processor 111 performs detection functions.

Controller information to operate tracking scheduler 102a, downlink scheduler 106a, and searcher scheduler 110a, are provided by address list input 142, and hardware parameters input 144. The delivery of the inputs can be provided by a variety of different sources and mediums, as described in subsequent figures.

Hardware resources 102b, 106b, 110b, and 111b are applied to a single computation process within a given system cycle in one embodiment. However, in another embodiment, hardware resources 102b, 106b, 110b, and 111b can be enhanced by running them at a clock rate higher than that required by a process in a given system cycle. That is, the hardware resources can be operated at a frequency that is higher than the data rate for a communication protocol implemented on communication device 100a. In this manner, resources of individual computation components, a receiver processor, can be time-shared across multiple computation processes, e.g., several multipaths and/or multiple channels. Additional information on the design and implementation of configurations into a configurable communication device is provided in co-pending US patent application serial number 09/492,634 entitled "Improved Apparatus and Method for Multi-Threaded Signal Processing" by Subramanian et al., filed January 27, 2000. This related application is commonly assigned,

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and is hereby incorporated by reference. More detail on time-sharing of hardware resources is described in Fig. 1C. By using the software-based allocation and scheduling of hardware resources, communication device 100a benefits from flexible and dynamic use of hardware resources that saves power, improves performance, allows changes of controlling algorithms,
5 and provides extended lifespan of the device.

Communication system 100a provides an exemplary embodiment of the present invention, which is well suited to alternative embodiments. For example, in other embodiments, communication system 100a is a mobile handset user equipment (UE), an embedded modem, or other communication device in another code-dependent application.
10 Furthermore, the present invention is applicable to any electronic device utilizing data processing operations.

Transmit processor 106, receiver processor 102, searcher processor 110, and matched filter processor 111 are exemplary processors used in communication device 100a. In another embodiment, software-based allocation and scheduling of hardware resources can be applied
15 to any function or quantity of hardware resources in an electronic device, as appropriate for a given application. Matched filter (MF) can also be referred to as a preamble detection engine (PDE).

Referring now to Fig. 1B, a block diagram of the components of a tracking processor that uses software-based allocation and scheduling of hardware resources, in accordance with
20 one embodiment of the present invention. Components of receiver processor 102 are described in Fig. 1B as exemplary components of a software-based allocator/scheduler of hardware resources.

Tracking scheduler 102a includes a memory block 152 coupled to a controller, or microprocessor (uP), block 154. Memory block 152 and uP block 152 have conventional
25 construction known to those skilled in the art in the present embodiment. For example,

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memory can be any kind of suitable memory such as flash memory, non-volatile memory, registers etc. By using a local controller 154, receiver processor 102 can operate quasi-autonomously from the balance of communication device 100a of Fig. 1A, and thereby reduce overhead and avoid interrupts.

5 Hardware resources 102b in the case of the tracking scheduler include multiple finger elements A 156a, B 156b, through finger element N 156n, where N is an arbitrary value depending upon the design of a system. The hardware resources can be any quantity and any function as needed by a given application. In one embodiment, N=3 for three finger elements, one each for early, on time, and late finger despreader/demodulators. The finger
10 elements are conventional fingers in the present embodiment, as is well known in the art. The fingers have appropriate selectable interfaces and parameterizeable interfaces to communicate enabling, control, state, and data signals from software in memory 152. The software-based allocation and scheduling of hardware resources is implemented by resident software in memory 152 being executed on controller 154 to allocate and schedule hardware resources
15 102b, e.g., the individual finger elements 156a through 156n. More than one table in memory 152 can be used to track and/or allocate the hardware resources in a given scheduler. This process is described in more detail in subsequent figures.

Tracking scheduler 102a is also referred to as an allocator, as described in co-pending US patent application serial number 09/772,584 entitled "A Wireless Spread Spectrum
20 Communication Platform Using Dynamically Reconfigurable Logic", by Subramanian et al., filed January 29, 2001. Additional information on the design and implementation of configurations into a configurable communication device is provided. This related application is commonly assigned, and is hereby incorporated by reference.

Elements 156a through 156n of hardware resource 102b include a conventional ASIC
25 portion 157 coupled to a programmable and distributed micro digital signal processing units

(micro DSP) 159 in the present embodiment. Both types of devices are coupled together to perform a desired function. The uDSP can perform repetitive functions, e.g., math operations, useful for a given application while the ASIC performs more function specific tasks for finger element 156a. Additional information on the content and function of a uDSP is provided in co-pending US patent application serial number 60/220,295 entitled "Distributed Micro Instruction Set Processor Architecture for High-Efficiency Signal Processing" by Chen et al., and filed July 24, 2000. This related application is commonly assigned, and is hereby incorporated by reference. In another embodiment, elements of hardware resources 102b can be either all ASIC or all uDSP or any combination thereof.

In another embodiment, hardware resources 102b, e.g., finger elements 156a through 156n, are limited to performing a single communication protocol, while in another embodiment, hardware resources are configurable to perform any one of a wide range of communication protocols. For example, co-pending US patent application serial number 09/751,783, entitled "A Configurable All-Digital Coherent Demodulator System for Spread Spectrum", by Ravi Subramanian, filed December 29, 2000, is configurable to accommodate a wide range of communication protocols. This related application is commonly assigned, and is hereby incorporated by reference.

Referring now to Fig. 1C, a graph of time showing multiple processing cycles within a given system cycle for the reuse of a hardware resource, in accordance with one embodiment of the present invention. Graph 160 provides an exemplary embodiment of implementing a scheduler to control hardware resources multiple times within a system cycle to obtain higher efficiency and throughput of data.

System cycle 162 is defined by a given application. For example, a communication protocol can have a system cycle with 2560 chips. However, the present invention is well suited to any length of system cycle that is defined by any variable, e.g., time, quantity of

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data, occurrence of events, etc. Each of the multiple virtual uses, 166, 168, through 170 of a single physical resource, e.g., hardware element A 156a, within a given cycle, e.g., a system cycle 162, can be referred to as a virtual resource. Even though only one physical resource exists, its use for multiple contexts, e.g., users, occurs within a given period of time, e.g., cycle 162, and thus appears to be a resource that is operating in parallel to an observer that simply looks for a result in a period of a system cycle. However, virtual uses actually occur in series as shown by the sequential nature of process 166b, 168b through 170b. Hardware element A is a physical finger element A 156a of Fig. 1B in the present embodiment.

Multiple processing steps shown in Fig. 1C range from virtual use 1 to virtual use M of hardware element A, where M is any value. In one embodiment, hardware element A 166a is a finger A 156A of hardware resource 102a of Fig. 1B. As shown, the clock speed of the hardware resources is relative to the system cycle and the number of intended uses, along with overhead and latency conditions. In equation form, this relationship is expressed as:

$$\text{Equation [2] Hardware Resource Clock Freq} = (1 / \text{System Cycle}) \times (M \text{ uses})$$

As an example, virtual use 1 166 can be for a first user requiring processing of a system cycle worth of on-time data in a finger, while virtual use 2 can be for a second user requiring processing of a system cycle worth of late data in a finger; and virtual use M can be a third user requiring processing of a system cycle worth of on-time data in a finger. Because all three are simultaneously needing data processing during a given system cycle and because flexible scheduler allows the reuse of hardware in real-time, e.g., as the system is operating, the present invention provides concurrent processing with a limited quantity of hardware to achieve a scale of efficiency.

Each virtual use includes a setup stage 166a, a process stage 166b and a save stage 166c. In the present embodiment, the setup stage of one use overlaps in time, that is to say it operates in parallel, to a processing stage of another use. In this manner, the processing

stages of sequential uses can be aligned to provide maximum processing use of hardware resources. The virtual use process is repeated in parallel for as many hardware resources are activated by a user or by the communication device. Thus, the total number of virtual resources of all hardware elements is M uses, of Fig. 1C times N elements of hardware resources 102b of Fig. 1B. In equation form, this relationship is expressed as:

Equation [1] Quantity of Virtual Resources = (M uses) x (N hardware resources).

By reusing hardware, a given system can be tailored to individual needs by scaling the clock rate and thereby the virtual resources created by the multiple processing cycles with a given system cycle. M can be any value for a given application. The greater the number of virtual resources required, the higher a clock rate for the resource can be scaled. Also, the greater the number of virtual resources, the greater the amount of memory required to store context data save from one virtual use, and used to setup the virtual use for the next system cycle. Because each virtual use of a given hardware element is completed within a given system cycle, they appear to be performed in parallel as concurrent operations, though only a single hardware resource is used. More information on time-sharing of hardware resources is described in co-pending US patent application serial number 60/222,007 entitled "Method and Apparatus for Time-Sliced and Multi-Threaded Data Processing in a Communication System," by Rieken et al., filed July 31, 2000. This related application is commonly assigned, and is hereby incorporated by reference. Additional information is also provided in co-pending US patent application serial number 09/492,634 entitled "Improved Apparatus and Method for Multi-Threaded Signal Processing" by Subramanian et al., filed January 27, 2000. This related application is commonly assigned, and is hereby incorporated by reference.

The present invention is well suited to using any quantity of virtual uses for any time period desired, for any hardware element and for any system cycle condition. Furthermore, alignment of processing, setup, and save stages can have a wide range of alignment features,

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embodiment, interface 209 is a wireless transmission from external processor device 202, or another communication device, e.g., a wireless base station or wireless test platform. In another aspect of the present invention, configuration information is provided at the time configurable communication device 100a is manufactured and/or initially programmed for operation in the field, for the present embodiment. However, in another embodiment, configuration information is dynamically implemented at a time configurable communication device 100a is in operation in the field.

Referring now to Fig. 2B, a block diagram of a computer used to generate code for software-based allocation and scheduling of hardware resources communication device is shown, in accordance with one embodiment of the present invention. Fig. 2B provides one embodiment of external processor device (computer) 202 of Fig. 2A. By using computer 202, the present invention can process user information to generate a desired controller configuration for a data processing device such as communication device 100a of Fig. 1A.

Computer system 202 includes a core computing device 220 which includes a control/data bus 222 for communicating information, a central processor unit 214 for processing information and instructions, coupled to bus 222, and a memory unit 216 for storing information and instructions, coupled to bus 222. Memory unit 216 can include memory configuration such as random access memory (RAM) for storing temporal information and instructions for central processor unit 214. Complementally, non-volatile memory 218 can include a memory configuration that is read only memory (ROM), for storing static information and instructions for central processor unit 214. Data storage unit 210 can store program instructions and large data base type information.

Computer system 202 also includes an optional display device 218. Display device 218 can be any type of display, such as an analog or a digital display unit. Computer system 202 also includes an optional input device 226 that is coupled to bus 222. Optional input

device 226 can include any input device, e.g., an alphanumeric input device such as a keyboard, or a cursor control device such as a mouse, etc. Optional input/output signal unit device 212 provides a communication interface from computer system 202, e.g., serial port, etc.

5 Bus 222 provides an exemplary coupling configuration of devices in computer system 120a. Bus 222 is shown as a single bus line for clarity. It is appreciated by those skilled in the art that bus 222 can include subcomponents of specific data lines and/or control lines for the communication of commands and data between appropriate devices. It is further appreciated by those skilled in the art that bus 222 can be a parallel configuration, a serial
10 configuration, and that bus 222 can include interconnects, gateways, and/or translators as appropriate for a given application.

It is also appreciated that computer system 202 is exemplary only and that the present invention can operate within a number of different systems such as a general purpose computer system, a dedicated work station, an embedded control system, etc. Furthermore,
15 the present invention is well suited to using a host of intelligent devices that have similar components as exemplary computer system 202.

By using the computer, the appropriate outputs can be quickly and accurately generated from the inputs. Thus, many tasks, e.g., timing estimates, formatting, debugging, etc., can be automated for the development of a controller scheduler. With a GUI, these tasks
20 can also be menu driven, thereby enhancing user convenience.

Referring now to Fig. 2C, a block diagram of a function that generates code for software-based allocation and scheduling of hardware resources, in accordance with one embodiment of the present invention. Function 230 enables the generation of a controller configuration by evaluating trading off and reconciling desired settings versus resources.

Function block is implemented on exemplary computer system 202 of Fig. 2B in the present embodiment. However, it can be implemented on any electronic device having a processor and memory sufficient to accommodate the controller commands of a given application.

5 Function block 230 performs a host of sub functions including but not limited to: receiving inputs, reconciling inputs with each other, structuring data, formatting data, debugging data, and outputting data. Inputs provided to controller configuration function 230 include a quantity of available hardware resources 232a, control information 232b, desired quantity of hardware resources 232c, computing resources 234a, and protocol format 234b in
10 the present embodiment.

With respect to input 232a, a quantity of available hardware resources 232a can be provided to function 230. For example, 'N' instances are available for exemplary hardware resources 102b of Fig. 1B. The quantity of available uses includes virtual uses of physical hardware resources, as illustrated in Fig. 1C. The specific partitioning of physical hardware
15 resources and virtual uses thereof can be hidden from a user in one embodiment. The virtual resource is identical to physical resource from a user perspective when the management of the virtual resource is performed by software controls as described herein.

Any quantity of available hardware resources can be provided as input 232a, provided it exists in a given application, or as artificially designated by some higher-level management
20 of hardware. The desired quantity of hardware resources 232c may be derated, e.g., at output quantity of virtual uses 246, from the maximum possible resources for accommodating anticipated volume growth in the future, for accounting for normal degradation of device performance over time, or for different quality of service levels. A default value may be set for any of the above cases.

Input of control information 232b includes information related to implementing parameters for hardware resources via the software controller. For example, control information can include overhead information and sequencing information of multiple virtual uses, such as the overlapping stages shown in Fig. 1B. Control information can indicate configuration settings for configurable hardware resources in order to conform to a desired one of many possible communication protocols, e.g., as described in Fig. 1B. Control information can include user-defined parameters, performances and proprietary and non-proprietary algorithms including information such as threshold values, coefficient values, filter order, etc. The control information input 232b can include management algorithms that account for dynamic changes in control of the flexible scheduler. For example, the conditions under which a hardware resource, such as a finger, is dropped and thus skipped by the controller may be indicated in the control information input. This input can affect quality of service provided by the communication device, as well as other performance metrics. The dynamic implementation of the control information is explained in subsequent tables and flowcharts.

Input of desired quantity of hardware resources 232c is provided by the user as any value equivalent or less than the maximum number of resources available in the system in one embodiment defined by input 232a. Similarly, input of computing resources 234a accounts for any one of many possible computing resources used in a data processing device for which flexible control is desired. For example if a power PC processor is utilized as the host microprocessor 130 of communication device 100a of Fig. 1A, then control information that interacts appropriately with the constraints and special commands of the power PC processor are provided to the function.

Protocol format input 234b provides protocol format, which includes the appropriate word lengths and structure appropriate for the memory, e.g., 152, used in tracking scheduler

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102a. More information is provided on the specific structure of the memory and information stored thereon for controlling, in subsequent Figs. 3A and 3B.

Address link output 142 provides the formatting and instructions for generation of a software-based allocator/scheduler in a communication device, e.g., 100a of Fig. 2A.

5 Parameter settings output 144 provides the appropriately formatted user-desired settings obtained from control information input 232b, for the desired hardware resource.

The controller configuring function 230 can be used for any quantity of functions controlled by a dynamic scheduler in a given data processing device, assuming the appropriate inputs, protocol format, etc. reflect the instant hardware resource. The
10 inputs/outputs shown in Fig. 2C are exemplary, and greater or fewer inputs and outputs can be provided for either a more fixed or predetermined design or a more flexible design.

CONTROLLER MEMORY LAYOUT

Referring now to Fig. 3A, a table of computer memory fields that store code for software-based allocation and scheduling of hardware resources, in accordance with one
15 embodiment of the present invention. Table 300A provides an exemplary embodiment of information stored in memory, e.g., memory 152 of Fig. 1B, to provide software-based allocation and scheduling of hardware resources.

Some columns in table 300A are descriptions of what memory storage represents, such as physical resource column 302, virtual use column 304.

20 Physical resource column 302 refers to the physical resources desired, e.g., a finger element, as determined by function block 230 of Fig. 2C. Virtual use column 304 refers to the time slot of a given system cycle which is using the hardware resource. Thus, for example, virtual use 1 314a represents one use of physical resource set 312 of Finger A, Finger B, through Finger N. Fig. 1C shows the virtual use 1 166 in a time domain of a single
25 hardware element A, e.g., a finger element 156a, that is shown in the physical domain in Fig.

1B. Addresses 322 lists of the addresses of a given row. Thus, the first row has a memory address of '0001'.

Other columns in table 300A represent the information, or class of information, that is actually stored in the memory buffers, e.g., memory 152 of Fig. 1B. For example, column 306 entitled hardware (H/W) control parameters set by software (S/W) represents a category of information stored in table 300A. In one embodiment, contents of column 306 are provided by a user via inputs 232a -232c in function block 230 of Fig. 2C in conjunction with computer 202 in Fig. 2B, in one embodiment. Parameters in column 306 can include hardware resource configurations required to conform to one of multiple possible communication (e.g., 3GPP) or data processing (e.g., IEEE 802.1 lb) protocols. Parameters in column 306 can also be user-defined performances, such as thresholds or state changes, as well as user-defined proprietary algorithmic settings for hardware within a given communication protocol. A user can be defined as a system operator, an infrastructure provider, or any other entity associated with the operation of a device using the flexible scheduler. In one embodiment, the possible settings for the function blocks are defined in Appendix A of the CBE, incorporated by reference hereinabove.

Another class of information is the H/W control parameters set by hardware 308. Column 308 includes data from internal components of communication device 100a such as from parameter estimators 112 as shown in Fig. 1A, in the present embodiment. In this embodiment, parameter estimator 112 will provide data, stored in column 308 for a given channel, e.g., data from channel estimator, the frequency lock loop, the phase lock loop, and other devices/functions that promote proper processing of the data signal. States of devices used in virtual uses will also be stored in this column. For example, code generator unit (CTU) states that will ensure the continuation of a code sequence at an appropriate point is stored such that virtual uses may continue the sequence seamlessly. Lastly, the first address

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link list column 310 stores addresses for the next executable row of data for any given row of data, thereby allowing sequential steps or jump steps to information allocating and scheduling of the hardware resources. The arrows and function of the first address list is explained more fully in flowchart figures described hereinafter.

5 Each row represents a unique combination of both a hardware resource and a virtual use. Thus, equation [1] referred to above, indicates the number of rows necessary, e.g., $M \times N$ rows. Each row has data entries listed for each the columns described hereinabove. The entire table 300A is traversed according to the link list sequence within a given system cycle, e.g., cycle 162 of Fig. 1C, in the present embodiment.

10 The allocation and scheduling information for a given hardware resource located within a row of data from table 300A can be referred to as a 'word' of information. Hardware resources, e.g., 102b of Fig. 1B, can implement data from a word of data transmitted by Table 300A by selectively reading the predetermined portions of the word of information at the appropriate component of hardware, in the present embodiment. Output from the table can be
15 a 32-bit word, with 16 bits from column 306 and 16 bits from column 308. The first 16-bit portion from column 306 can be selectively extracted from the word of data and supplied to the appropriate controllable portion of the hardware resource using a mask circuit or other similar means.

 While the present embodiment provides specific columns for parameters set by both
20 hardware and software, the present invention is well suited to having any columnar format with any kind of parameters stored in software that will accommodate the needs of the hardware resources for a given electronic device in a given application. Furthermore, while the present embodiment shows virtual uses of physical hardware resources, the present invention is well suited to implementing table 300A for just physical hardware resources.

The quantity of bits of data stored and provided by table 300A can be any value, as determined by a user and implemented in memory.

By using software, e.g., a table of rearrangeable data in memory, to control hardware resources the amount of control and flexibility available to a user increases significantly.

5 Furthermore, the control parameters and information themselves can quickly and easily be changed by inputs from either a user or other hardware components. Thus, rather than building a new controller for a different sequence, a quick and efficient software change can accommodate the new control sequence and parameters for hardware resources. This paradigm saves cost, design time, infrastructure, and other resources while improving
10 customer support, lengthening lifespan of a device, and enabling new technologies to be implemented in a given device.

Referring now to Fig. 3B, a table of computer memory fields that allow dynamic changes in the software-based allocation and scheduling of hardware resources is shown, in accordance with one embodiment of the present invention. Table 300B of Fig. 3B is similar
15 to Table 300A of Fig. 3A, with the addition of a column entitled second address link list 320. By having multiple columns of linking address lists, changes to the controller can be dynamically implemented, e.g., without interrupting the real time operation of the electronic device being controlled, while maintaining integrity and robustness of the electronic device. Thus, a device having a dynamic controller with memory similar to Table 300B can be very
20 responsive and efficient to changing environments and system loads. In this manner, user performance is enhanced while resources are conserved. Any number of address link lists can be generated, thereby providing multiple possible control processes from which a higher-level controller or processor may choose.

Referring now to Fig. 3C, a table of computer memory fields that provide a hierarchy
25 of software-based allocation and scheduling of hardware resources is shown, in accordance

with one embodiment of the present invention. Fig. 3C includes an ID table 350, a resource A table 352 and a resource B table 354. ID table 350 includes a column for ID in which entries for ID-1, ID-2, and ID-N are shown. Resources tables 352 and 354 have a link in column 383 that point to the ID table. When a new user, e.g., mobile, first requests use of hardware resources in communication device 100a, their IDS can be entered into table 350 to allow tracking of the user for multiple processes and hardware resource allocations throughout the communication device. Pointers in the resource tables 352 and 354 provide a backtracking reference of determining the user.

Referring now to Fig. 3D is a table of computer memory fields that track users of software-based allocation and scheduling of hardware resources, in accordance with one embodiment of the present invention. Primary table 380A lists groups of hardware resources by a group identification in column 381 and by a pointer to a secondary table that identifies the start location for the control information on the hardware resources slated for the group. Primary table can provide a reference back to an ID table, e.g., table 350. The last entry in primary table is for B, after which the first line in primary table is resume, e.g., pointer end traverses to the first line of the table. Secondary table includes an on/off column to turn control parameters for a hardware resource either on or off. No link list is listed in column 389 for all the entries in a group, e.g., first block A 370. This is because each entry has a default pointer to the next line in the table. In this manner, total flexibility throughout the table is eliminated at the benefit of ease of implementation and speed through which the table may be traversed. However, a link address can be implemented for any line of a hardware resource. This list can be referred to as a chunk list in that all the hardware elements in first block A 370 are implemented in a sequential fashion as the default address link sequence. While the present embodiment provides a specific quantity of table and columns in each table, the present invention is well suited to utilizing more or less columns with different

types of information for other purposes. The flexibility and implementation ease of the present invention is still maintained with these alternative embodiments. Additional information on the design and implementation of primary and secondary tables 308A and 380B respectively, is provided in co-pending US patent application serial number 60/222,853
5 entitled "Dynamically Reconfigurable Universal Transmitter System" by Medlock et al., filed August 3, 2000. This related application is commonly assigned, and is hereby incorporated by reference.

PROCESSES

Figs. 4A through 4C are flowcharts of processes that can be implemented on
10 exemplary functions and/or hardware of Figs. 1A through 3B. Referring now to Fig. 4A, a flowchart of a process that operates a software-based allocator/scheduler of hardware resources in an electronic device is shown, in accordance with one embodiment of the present invention. By using flowchart 4000, the present invention allows hardware resources in an electronic device to be flexibly controlled, thereby allowing a system to be tailored to a wide
15 range of changing variables.

Flowchart 4000 begins with step 4002. In step 4002 of the present embodiment, the initial address is located in memory. Step 4002 is implemented by a higher-level controller/microprocessor locating the first line of the controller instruction. In one embodiment, controller 130 of communication device 100a in Fig. 1A locates the first line of
20 controller memory, with address '0001' represented literally in address column 302 for controlling hardware resources 102b of receiver processor 102. Step 4002 can be implemented by local controller 154 of Fig. 1B in another embodiment. Step 4002 can also be implemented by another table in memory 152 providing a pointer, such as that shown in Fig. 3C by primary table 380A for Group A pointer to location of '0001' in secondary table
25 380B. Following step 4002, flowchart 4000 proceeds to step 4004.

In step 4004 of the present embodiment, the information associated with address for controlling a hardware resource is transmitted. Information includes hardware (H/W) parameters from software (S/W) output 4004a and H/W parameters from H/W output 4004b in the present embodiment, as defined for column 306 and 308 respectively in Fig. 3A.

5 However, step 4004 can include fewer or greater parameters as well as different types of parameters in another embodiment. Tracking scheduler 102a is hard coded to the finger elements 156a through 156n of Fig. 1B, with appropriate interface to accommodate the virtual use context switching over time. Step 4004 can include a setup stage to provide parameters and state information to the hardware resource for the given user profile accessing the
10 hardware resource, e.g., the virtual resource for this particular use. By using a setup stage, processing for one virtual use, e.g., virtual use 1 166, can occur while a subsequent virtual use is being setup in memory local to the hardware for another virtual use, e.g., virtual use 2 168, as shown in Fig. 1 C. Following step 4004, flowchart 4000 proceeds to step 4006.

Flowchart 4000, and tracking scheduler 102a, does not utilize a conventional
15 handshake protocol in the present embodiment to confirm completion of a given process, e.g., process 166b, for a given virtual use, e.g., virtual use 1 166, as shown in Fig. 1C. Rather, by limiting the virtual use to a predetermined length of time, the scheduler assumes that a given virtual use is completed after the elapse of the predetermined time. In the present invention, the processing stage, e.g., 166b of Fig. 1C, is limited apriori to a specific quantity or duration
20 of processing to ensure completion of all processing cycles of all virtual uses within system cycle 162. However, the present invention is well suited to using a handshaking protocol to confirm completion of a processing stage.

In step 4006 of the present embodiment, an address link is read from the row currently being implemented. The address link indicates the location of the next row whose
25 information is to be read and transmitted. For example, if the first row, e.g., row address {W:\04303\100N160-000\00096420.DOC [REDACTED] }

'0001' is being read from Table 300A in Fig. 3A, then the linking address of '0010' is read from the first link address link list 310. The linking address happens to be the next sequential row in memory in the present embodiment, and thus an effective path 316 is followed in table 300A. In contrast, Table 300B of Fig. 3B shows an embodiment where row address '1000' has a second address link of '0001' in column 320 which effectively skips the rows with addresses between '1000' and '1010' as illustrated by path 324. This situation may have arisen because a user had a poor performance of a multipath signal, and thus fewer fingers are necessary to process data from that user. A similar bypass occurs as shown by path 326.

In another embodiment implementing step 4006, the linking address for an entry automatically moves as the next row within a group. For example, first block A 370 in Fig. 3D includes all physical resources of Element A through Element B in column 384 for a Virtual Use, or time slot, of '1' in column 385. Each physical resource has a link address to the next element in this group. A different link may be established for any entry in the group to override the default link to the next element. This latter embodiment reduces overhead in that the link is predetermined. Following step 4006, flowchart 4000 proceeds to step 4010.

In step 4010 of the present embodiment, an inquiry determines whether after the hardware resource is done running, the hardware resource still needs to be reused within the current system cycle. If a given hardware resource is reused within a system cycle, then flowchart 4000 proceeds to step 4012. Alternatively, if the given hardware resource is not reused within the system cycle, then flowchart 4000 proceeds to step 4014.

In step 4012 of the present embodiment, the hardware resource information from the current use is saved. The hardware resource information can include states and timing information of the process being executed that are required to continue the process in the next cycle for the given user, e.g., mobile. The save stage saves appropriate parameters and states of the hardware resource following the processing stage. The setup and save stages of a use

of a given hardware resource are performed in parallel with a process. Step 4012 is implemented in one embodiment by save stage 166c for virtual use 1 which is occurring at the same time that setup stage for virtual use 2 is loading data into finger A 156A in Fig. 1B from memory 152, for hardware resource to utilize. The setup and save can use local cache (not shown) in element, e.g., finger A 156A in one embodiment. Alternatively, any type of series or parallel processing is possible, given the appropriate memory and communication lines. The state and timing information can be saved in column 306 of table 300B.

In step 4016 of the present embodiment, control is advanced to the subsequent address. In the present embodiment, the link address can move control anywhere in the table as shown in Fig. 3A. In another embodiment, the link address simply moves to the next executable line in the table that has been predetermined. This latter embodiment can provide a change in the link address at either all entries or only at certain break points, e.g., at the end of a group of elements such as group block A 370 of Fig. 3D. Following step 4016, flowchart 4000 returns to step 4004.

In step 4014 of the present embodiment, an inquiry determines whether the operation should be terminated. If the operation should be terminated, then flowchart 4000 ends. If, on the other hand, the operation should not be terminated, then flowchart 4000 proceeds to step 4018. Step 4014 provides logic for flowchart 4000 to repeatedly execute lines of control information for subsequent virtual uses of hardware resources. Step 4014 also provides the logic for flowchart 4000 to cease the execution of lines and return control to some external entity, e.g., host controller or a higher-level scheduler table such as primary table 380A. Table 300A provides an pointer at the end of the table entries, and it points back to an appropriate starting location, as shown by path 317.

In step 4018, control is advanced to a subsequent system cycle. Step 4018 is implemented by local controller 154 reading an end pointer and returning to some higher

level table, e.g., primary table 380A, or higher level controller, e.g., host controller 130. Only the last element desired to be implemented the link address of 'end' or 'null' in column 389 that returns it to the primary table 380A. The end pointer can exist at the end of a group of elements, e.g., block A 370, or can exist only at the end of a list of all elements. By using a
5 pointer, the present system does not need interrupt signals because control is passed with known steps. This process also makes changes in the sequence and allocation of elements easier to implement because the changes can be made at the predetermined times and implemented at known cycles of the control handoff.

Referring now to Fig. 4B, a flowchart of a process that generates a software-based
10 allocator/scheduler of hardware resources for a communication device is shown, in accordance with one embodiment of the present invention. Flowchart 4100 can be implemented using computer system 202 to implement some of the software-based allocator/scheduler configurations to be implemented in a communication device. Other steps of flowchart 4100 can be executed on the actual communication device itself, e.g., device 100a of Fig. 1A. This
15 allows a user to remotely design a software-based allocation and scheduling system for hardware resources in a communication device as described in Figs. 1A and 1B.

Flowchart 4100 begins with step 4102 wherein a quantity of available hardware resources is received. Quantity of available hardware resources is described for input 232a in Fig. 2C. In one embodiment, only physical hardware resources are considered in step 4102
20 while another embodiment additionally considers virtual uses of the physical hardware resources. Following step 4102, flowchart 4100 proceeds to step 4103.

In step 4103, a list is generated in memory for linking requests to a hardware resource. Step 4103 is implemented in one embodiment by generating one or more lists in memory 152 of tracking scheduler 102a in communication device. In one embodiment, a list such as table
25 300A is generated listing all the virtual resources available for the given function, e.g.,

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fingers. In another embodiment, a table such as primary table 380A is created to track the group allocation or identity, e.g., group column 381, while a secondary table is also generated that maps out either the entire virtual use space or a predetermined blocking of virtual uses. For example, ID table 350 of Fig. 3C can be set up to list identification information and tie

5 processes, e.g., searcher processor functions and receiver processor functions, through communication device 100a to a given user or mobile via table 350. Subsequent secondary table 380B can map out 3 fingers as a default group size of hardware resources provided to a group, e.g., a mobile, for either the entire quantity of hardware resources, e.g., virtual uses included, or a fraction thereof with a reserve quantity available for dynamic changes.

10 In step 4104, a desired quantity of hardware resources to be operated in target device is received. The desired quantity of hardware resources can account for virtual uses beyond the quantity of the physical hardware resources themselves. The desired quantity of hardware resources is provided as input 232c to the controller configuring function 230 of Fig. 2C. The desired quantity of hardware resources is limited in the present embodiment to the maximum

15 number of the total virtual uses of the physical hardware resources. The desired quantity of hardware resources is also provided in communication device 100a when the software-based allocator/scheduler is implemented. Typically the desired quantity of hardware resources changes during operation of communication device 100a, and thus is a dynamic process. Following step 4104, flowchart 4100 proceeds to step 4106.

20 In step 4106 of the present embodiment, operation information for operating each of the hardware resources is received. Operation information, which can include control information, that is received includes semi-static hardware parameters 4106a input, e.g., hardware control parameters set by software of Table 3A. Operation information is described as parameters set for column 306 of Fig. 3A in one embodiment. That is, input 4104 is

25 provided in column 306 of Table 300 in Fig. 3A and as input 232b in Fig. 2C. In the present

embodiment, all the control parameters for a given function are the same. However in another embodiment, the control parameters can be different for different channels, e.g., tailored depending on type of user, application, etc. within the communication device. This operation information is generated in one embodiment by Figs. 2B and 2C and stored as controller information 203 in external processor device 202, and communicated via medium 209 to communication device 100a as shown in Fig. 2A. A user can provide this operation information input per proprietary or well-known algorithmic solutions to a given data processing application, including but not limited to wireless communication. Operation information generated externally can be received in terms of parameter settings 144 at communication device 100a. Following step 4106, flowchart 4100 proceeds to step 4107.

In step 4107 of the present embodiment, a request is received to use hardware resources. Step 4107 is implemented in the present embodiment by communication device 100a of Fig. 1A receiving a request from host processor 130 or from tracking scheduler 102a, e.g., via a primary table 380A that has now read a pointer to enable secondary table execution of hardware resources. If a new mobile device is trying to communication with communication device 100a for the first time, its ID can be entered on ID table 350 of Fig. 3C, with subsequent assignment of fingers from secondary table 380B. Resource table B 354 can be a separate table that allocates the fixed number of hardware resources. A pointer from the resource table 354 points to the ID table to indicate the identification of the user for the applicable hardware resources. Following step 4107, flowchart 4100 proceeds to step 4108.

In step 4108, a pointer is generated for operation information of a hardware resource. Step 4108 can be implemented by primary table 380A of Fig. 3D that generates a start pointer in column 382 for a new group or user ID that desires to use the resources controlled by secondary table. Alternatively, the hardware resource information can be added into an existing group with open or unused virtual resources. For example, unused element N for {W:\04303\100N160-000\00096420.DOC }

virtual use 1 has an 'off' flag in column 386 and thus may be implemented for a new request that needs only one hardware resource. The hardware resource is one virtual use of a physical hardware. Following step 4108, flowchart 4100 proceeds to step 4110.

In step 4110, an inquiry determines if the desired quantity of virtual hardware
5 resources have been linked. If the desired quantity of virtual hardware resources has been linked, then flowchart 4100 proceeds to step 4114. However, if the desired quantity of virtual hardware resources has not been linked, then flowchart 4100 proceeds to step 4112. Step 4110 ensures that the desired quantity of virtual hardware resources exist and have been linked to provide an initial link list that has continuity, e.g., no hardware resources have been
10 skipped unintentionally. In one case, only a fraction of the hardware resources are made available for an initial assignment for requests, with a reserve quantity available for dynamic changes. In the present embodiment, only physical hardware resources are used at first, and only after they are all consumed, will virtual uses be instantiated.

For example, if two physical resources existed that could be utilized in two virtual
15 uses, and then four virtual resources are available. If a mobile only wanted two virtual uses, then either both hardware resources could be used with no virtual reuse or a single hardware resource could be used with two virtual uses. The present invention is well suited to any combination or use of the hardware and virtual uses to satisfy a desired need.

Step 4112 arises if the desired quantity of virtual resources has not been linked per
20 step 4110. In step 4112, an address link to control information for a subsequent hardware resource is associated with the control information for given hardware resource. Following step 4112, flowchart 4100 returns to step 4107.

In step 4114 of the present embodiment, control information is generated for the last hardware. Step 4114 can generate end or null statements at the end of each group of
25 hardware as shown in Table 380B column 389 that points back to a primary table.

Alternatively, the last hardware resource may simply point back to the beginning of a list, as shown in Fig. 3A, without the use of a primary table. Following step 4114, flowchart 4100 ends.

Referring now to Fig. 4C, a flowchart of a process for dynamically changing the software-based allocator/scheduler of hardware resources in an electronic device is shown, in accordance with one embodiment of the present invention. Flowchart 4200 is implemented in the present embodiment using communication device 100a of Fig. 1A. By using flowchart 4200, flexible scheduler in communication device 100a can be dynamically changed, e.g., without interrupting the real time operation of the electronic device being controlled, without any detectable change in performance for existing processes. Furthermore, the dynamic changes can be implemented while still providing robust and reliable operation.

Flowchart 4200 begins with step 4202, wherein a first address link list is received in the present embodiment. Step 4202 is implemented by receiving a first address link list via medium 209 described in Fig. 2A, and stored in memory in first address list column 310 as shown in Fig. 3B. First address link list is described as outputs from Fig. 2B, and is received as address link input 142 and parameter input 144 shown in Fig. 1A. The first list of pointers is chosen as the default active list in the present embodiment. Following step 4202, flowchart 4200 proceeds to step 4204.

In step 4204 of the present embodiment, a second address link list is provided as a backup to the first address link list. Second address link list can be internally generated as a simple copy of the first list of address links in the present embodiment. Alternatively, an entirely separate and independent second address link list can be received by communication device in a manner described in step 4202. Step 4204 is implemented similarly to step 4202, but stored as second link address list 320 as shown in Fig. 3B. Second address link list is backup to complement the first address link list. Step 4204 is applicable for software-based

allocator/scheduler of Fig. 3B. However, it is not required for secondary table 380B of Fig. 3D. Following step 4204, flowchart 4200 proceeds to step 4206.

In step 4206 of the present embodiment, the hardware resources of the electronic device, e.g., the communication device, are operated using the active list of pointers. Step 4206 is implemented in the present embodiment using the process described in flowchart 4000 of Fig. 4A. Selection of which address list is active is controlled by a higher-level controller or processor, such as the host processor 130 of communication device 100a of Fig. 1A. Any combination of tables in Fig. 3A through 3D can be utilized for performing the allocating and scheduling functions for the hardware resources. Following step 4206, flowchart proceeds to step 4208.

In step 4208 of the present invention, an inquiry determines whether changes are desired for control of the hardware resources. If changes are desired to the control of the hardware resources, then flowchart 4200 proceeds to step 4210. However, if changes are not desired to the control of the hardware resources, then flowchart 4200 returns to step 4206. A change can arise due to the movement of a mobile device into another sector of a communication device, e.g., base station, receiving its signals. Alternatively, a change can arise due to hardware resource changes in the communication device. Step 4208 is implemented by a higher-level controller, e.g., host controller 130, receiving information that requires a change.

In step 4210 of the present embodiment, the address links for the hardware resources are modified per the desired change. In one embodiment, linking addresses such as those in first address link list 310 of Fig. 3B can be modified. Alternatively, an on/off flag can be toggled in column 386 of Fig. 3D for a chunk list operation. Thus, step 4210 is implemented in the present embodiment, by making changes to the second address link list to either bypass over hardware resources or virtual uses thereof, or alternatively to relink hardware resources

or virtual uses that were previously bypassed. Changes for hardware resources can also be accomplished in primary table 380A of Fig. 3D. In this case, if a group does not need hardware resources, it can be removed from the primary table list.

Inputs to step 4210 include new link list address 4210a. New link list address
5 provides either an entire link list or a change to an individual address link. Either link list can be the backup list rather than the active list. The backup list is the list that is changed because it is not being used for actively controlling the hardware resources. Thus, prior to implementing changes control logic identifies the passive list of address links. This paradigm allows changes to be implemented by the present invention in real time, while the electronic
10 device and hardware resources are currently being controlled by the active address link list. Fig. 3B illustrates how the row with address '1000' for Finger B virtual use 2 has a linking address of '1001' for first link address list 310. However, this same row has received a change for the second link address list 320 from some previous linking address to a new linking address of '1010.' Consequently, path 324 is followed when executing table 300B,
15 thereby bypassing last rows with addresses between row address '1000' and '1010'. This change could have occurred for any one of a number of reasons ranging from quality of service to poor reception, all under the potential high-level management of user-defined criteria. For example, a poor multipath performance may have necessitated the dropping of a finger resource for the given user. Alternatively, hardware resources currently bypassed in
20 Table 300B may now be reintroduced into the sequencing of the address link list to accommodate a new channel that will now utilize fingers of Fig. 1B that were previously idle, e.g., hardware resources between row address '1000' and '1010'.

In step 4212 of the present embodiment, an inquiry determines whether changes are desired immediately. Step 4212 is implemented by use of a status flag or a check bit that is
25 evaluated by local controller 154 of Fig. 1B, but may also be implemented by a hierarchical

controller, e.g., the host controller 130 of Fig. 1A. Step 4212 allows for either accumulating non-critical changes to the address link list over time or for implementing an urgent change in the link list immediately. In this manner, the controller can be as responsive as the user desires. Accumulating non-urgent changes has the effect of conserving power and avoiding
5 excessive switchovers between link lists. In another embodiment, change requests are implemented by default at the next non-operating period of a given list, e.g., primary table 380A. If a change is desired to be implemented immediately, the flowchart 4200 proceeds to step 4214. However, if a change is not desired to be implemented immediately, then flowchart 4200 returns to step 4206.

10 Step 4214 of the present invention arises if the changes desired for the controller are implemented immediately. In step 4214 of the present invention, the active and passive status of the first address link list and the second address link list is exchanged. Step 4214 is implemented similarly to step 4212 where a higher-level controller 130 of Fig. 1A, or the local controller 154 of Fig. 1B, indicates the controller which address list is the active list.

15 The implementation of the change from one address list to another address list occurs at the initial row of the table in the present embodiment. Thus, for example, the active address link list won't change midway down table 300B. However, the present invention is well suited to any type of changeover procedure from one list to another. For example, one list can be an active list used to actively control the hardware resources while the second list can be a
20 passive list, accepting changes to the link list. Either address list can be active, with the other one being passive. For example, if row '0111' for Finger A at virtual use 2 is to be changed from a link address of '1000' to '0001' in second address link list 320 and is desired to be implemented immediately, then once first link address list 310 reaches the last row, e.g., row '1111' and is linked to the first row '0001', the higher level controller has implemented a flag

to make the second link address list 320 be the active list. Following step 4214, flowchart 4200 proceeds to step 4216.

Step 4216 of the present invention duplicates the active address link list into the passive address link list. Step 4216 is implemented as soon as the exchange of the active/passive status of first link address list 310 and second link address list 320 has been completed, in the present embodiment. Alternatively, the duplication of one list of address links can be performed immediately prior to a subsequent exchange step 4214. Following step 4216, flowchart 4200 proceeds to step 4217.

Step 4217 of the present invention inquires whether an error arises with the active list of pointers. If an error does arise, flowchart 4200 returns to step 4214. If an error does not arise, flowchart 4200 proceeds to step 4218. Step 4217 is effective if a newly created active list contains an error and the previous active list does not contain an error and has not been overwritten by the new active list. In this manner, the present invention provides a backup of an original controller configuration that can be utilized if an error occurs. Thus, the present invention provides robustness in its use of a configurable controller. Step 4217 is an optional step used to enhance the effectiveness of software-based allocation and scheduling. If a given hardware resource has a failure, then its use in the software based allocation/scheduling table can be modified to essentially eliminate it, and thus allow commutation device 100a to continue operation. This alternative can be implemented by turning off all virtual uses of the physical resource via column 286 in Fig. 3D.

Step 4218 of the present invention inquires whether the operation is terminated. Step 4218 provides for a hard restart, re-initialization, or some other power down of the communication device. If the operation is terminated, then flowchart 4200 ends. However, if operation is not terminated, then flowchart 4200 returns to step 4206.

While the present embodiment applies flowcharts 4000, 4100, and 4200 to a digital wireless communication system, the present invention can be applied to any electronic device for any type of application. Within the wireless communication system described in the present embodiment, the present invention is applicable to mobile units, base stations, and
5 test platforms. Furthermore, while flowcharts 4000, 4100, and 4200 of the present embodiment show a specific sequence and quantity of steps, the present invention is suitable to alternative embodiments. For example, not all the steps provided in the aforementioned flowcharts are required for the present invention. Similarly, other steps may be omitted depending upon the application. In contrast, the present invention is well suited to
10 incorporating additional steps to those presented, as required by an application, or as desired for permutations in the process. Lastly, the sequence of the steps for flowcharts 4000, 4100, and 4200 can be modified depending upon the application. Thus, while the present flowcharts are shown as a single serial process, they can also be implemented as a continuous or parallel process. For example, it is appreciated that the present flowcharts can be repeated
15 for each of multiple flexible schedulers in a given electronic device, e.g., three flexible schedulers 102a, 106a, and 110a of communication device 100a shown in Fig. 1A.

Many of the instructions for the steps, as well as the data input and output from the steps of flowcharts 4000 and 4200 utilize memory and processor hardware components, e.g. system memory 120 and processor 130 in Fig. 1A. A similar scenario exists for flowchart
20 4100 with respect to local memory 210 and local controller or processor 214 of computer 202 shown in Fig. 2B. The memory storage used to implement the flowchart steps in the present embodiment can either be permanent, such as read only memory (ROM), or temporary memory such as random access memory (RAM). Memory storage can also be any other type of memory storage, capable of containing program instructions, such as a CD ROM, or flash
25 memory, etc. Similarly, the processor used to implement the flowchart steps can either be a

dedicated controller, an existing system processor, or it can be a dedicated digital signal processor (DSP), as appropriate for the type of step. Alternatively, the instructions may be implemented using some form of a state machine.

Some portions of the detailed description, e.g., the processes, are presented in terms of procedures, logic blocks, processing, and other symbolic representations of operations on data bits within a computer or digital system memory or on signals within a communication device. These descriptions and representations are the means used by those skilled in the digital communication arts to most effectively convey the substance of their work to others skilled in the art. A procedure, logic block, process, etc., is herein, and generally, conceived to be a self-consistent sequence of steps or instructions leading to a desired result. The steps are those requiring physical manipulations of physical quantities. Usually, though not necessarily, these physical manipulations take the form of electrical or magnetic signals capable of being stored, transferred, combined, compared, and otherwise manipulated in a communication device or a processor. For reasons of convenience, and with reference to common usage, these signals are referred to as bits, values, elements, symbols, characters, terms, numbers, or the like with reference to the present invention.

It should be borne in mind, however, that all of these terms are to be interpreted as referencing physical manipulations and quantities and are merely convenient labels to be interpreted further in view of terms commonly used in the art. Unless specifically stated otherwise as apparent from the following discussions, it is understood that throughout discussions of the present invention, terms such as "locating," "transmitting," "reading," "repeating," "returning," "receiving," "generating," "associating," "operating," "implementing," "overwriting," "controlling," or the like, refer to the action and processes of a communication device or a similar electronic computing device, that manipulates and transforms data. The data is represented as physical (electronic) quantities within the

communication devices components, or the computer system's registers and memories, and is transformed into other data similarly represented as physical quantities within the communication device components, or computer system memories or registers, or other such information storage, transmission or display devices.

5 In view of the embodiments described herein, the present invention has been shown to provide a method and apparatus that coordinates, via allocation and scheduling, a wide range of hardware resources in an electronic communication device in a real time manner to accommodate a continual real-time flow of input data into the communication device and the resultant processed output data. Additionally, the embodiments show how the present
10 invention overcomes the limited flexibility of an ASIC controller in order to accommodate the variation in hardware resources and uses for the wide range of spread spectrum communication systems. The present invention also overcomes the effects of fragmenting hardware resources and the inefficient use of hardware resources, system interruptions, system crashes, and compounded fragmenting due to the dynamically changing environment.
15 And the present invention accommodates a dynamically changing environment while overcoming the limitation of comprised integrity of the system for processes that have not changed. Additionally, the present invention provides a method and apparatus of controlling hardware resources that provides user control and flexibility without the associated complexities and problems. Finally, the present invention overcomes the limitations of
20 inefficient manage the hardware resources in terms of power consumption.

The foregoing descriptions of specific embodiments of the present invention have been presented for purposes of illustration and description. They are not intended to be exhaustive or to limit the invention to the precise forms disclosed, and obviously many modifications and variations are possible in light of the above teaching. The embodiments
25 were chosen and described in order to best explain the principles of the invention and its

practical application, to thereby enable others skilled in the art to best utilize the invention and various embodiments with various modifications as are suited to the particular use contemplated. It is intended that the scope of the invention be defined by the Claims appended hereto and their equivalents.

5

CLAIMS

What is claimed is:

1. A method of controlling hardware resources in a device having a processor and a memory coupled to each other, the method comprising the steps of:

locating a first memory address in the memory associated with a first hardware resource;

transmitting control information associated with the first memory address to the first hardware resource; and

determining a pointer that is associated with the first address and locates a subsequent address associated with a subsequent hardware resource.

2. An apparatus for managing hardware resources in an electronic device having a controller and memory, the apparatus comprising:

means for locating a first memory address in the memory associated with a first hardware resource;

means for transmitting control information associated with the first memory address to the first hardware resource; and

means for determining a pointer that is associated with the first address and locates a subsequent address associated with a subsequent hardware resource.

3. In an electronic device having a processor, a memory, and at least one hardware resource coupled to each other, a method of dynamically implementing changes for scheduling the at least one hardware resource, the method comprising the steps of:

a) receiving a first list of addresses associated with the at least one hardware resource, the first list of addresses listing active operation information for the at least one hardware resource;

b) receiving a second list of addresses associated with the at least one hardware resource, the second list of addresses listing backup operation information for the at least one hardware resource;

c) receiving a request to modify an operation of the at least one hardware resource in a given category;

d) modifying the second list of addresses to reflect the request to modify the operation of the at least one hardware resource;

e) exchanging the active/backup status of the first list of addresses and the second list of addresses;

f) duplicating the active second address list as replacement for the backup first list of addresses; and

g) operating the at least one hardware resource according to the modified active-status second list of addresses.

4. An apparatus for dynamically implementing changes for scheduling at least one hardware resource in an electronic device having a controller and memory, the apparatus comprising:

means for receiving a first list of addresses associated with the at least one hardware resource, the first list of addresses listing active operation information for the at least one hardware resource;

means for receiving a second list of addresses associated with the at least one hardware resource, the second list of addresses listing backup operation information for the at least one hardware resource;

means for receiving a request to modify an operation of the at least one hardware resource in a given category;

means for modifying the second list of addresses to reflect the request to modify the operation of the at least one hardware resource;

means for exchanging the active/backup status of the first list of addresses and the second list of addresses;

means for duplicating the active second address list as replacement for the backup first list of addresses; and

means for operating the at least one hardware resource according to the active modified second list of addresses.

5. In an electronic device having a processor, a memory, and hardware resources coupled to each other, a method of operating the hardware resources comprising the steps of:

a) locating a current address in the memory, the current address containing operating information associated with a current hardware resource;

b) transmitting operating information associated with the current address to the current hardware resource; and

c) reading a pointer, which is associated with the current address, that identifies a subsequent address containing subsequent operating information.

6. The method of claim 5, wherein the method further comprises the step of:

d) determining whether the current hardware resource is reused within a system cycle.

7. The method of claim 6, wherein if the current hardware resource is reused within a system cycle, further comprising the step of:

e) saving the current hardware resource information from a current use; and

f) repeating steps b), c), and d) until the current hardware resource is not reused within a system cycle.

8. The method of claim 6, wherein if the current hardware resource is not reused within a system cycle, further comprising the steps of:

e) determining whether operation should be terminated; and

f) if operation should not be terminated, repeating steps a), b), c), and d) for a subsequent hardware resource that becomes the current hardware resource.

9. The method of claim 5, wherein the hardware resource is at least one of a searcher element, a downlink transmitter element, matched filter element, or tracker element.

10. An apparatus for dynamically implementing changes for scheduling hardware resources in an electronic device having a controller and memory, the apparatus comprising:

a) means for locating a current address in the memory, the current address containing operating information associated with a current hardware resource;

b) means for transmitting operating information associated with the current address to the current hardware resource; and

c) means for reading a pointer, which is associated with the current address, that identifies a subsequent address containing subsequent operating information.

11. The apparatus of claim 10, further comprising:

d) means for determining whether the current hardware resource is reused within a system cycle.

12. The apparatus of claim 11, wherein if the current hardware resource is reused within a system cycle, further comprising:

e) means for saving the current hardware resource information from a current use.

13. The apparatus of claim 11, wherein if the current hardware resource is not reused within a system cycle, further comprising:

e) means for determining whether operation should be terminated.

14. The apparatus of claim 10, wherein the hardware resource is at least one of a searcher element, a downlink transmitter element, matched filter element, or tracker element.

15. In a communication device having a processor, a memory, and hardware resources all coupled to each other, a method of generating a scheduler for managing the hardware resources of the communication device, the method comprising the steps of:

a) receiving a quantity of available hardware resources;

b) generating a list in the memory for linking requests to the hardware resources;

c) receiving a desired quantity of hardware resources to be operated in the communication device;

d) receiving hardware resources operation information;

e) receiving a request to use at least one of the hardware resources;

f) assigning a memory address to the hardware resource operation information for each of the hardware resources; and

g) linking the memory addresses of hardware resources.

16. The method of claim 15, wherein the list is a table listing all virtual resources available for a given function.

17. The method of claim 15, wherein the list includes a primary table and a secondary table, the primary table tracking a group allocation and the secondary table mapping virtual uses.

18. An apparatus for generating a scheduler for managing the hardware resources of the communication device having a controller and memory, the apparatus comprising:

a) means for receiving a quantity of available hardware resources;

b) means for generating a list in the memory for linking requests to the hardware resources;

c) means for receiving a desired quantity of hardware resources to be operated in the communication device;

d) means for receiving hardware resources operation information;

e) receiving a request to use at least one of the hardware resources;

f) means for assigning a memory address to the hardware resource operation information for each of the hardware resources; and

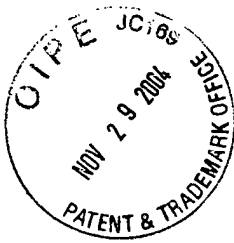
g) means for linking the memory addresses of hardware resources.

19. The apparatus of claim 18, wherein the list is a table listing all virtual resources available for a given function.

20. The method of claim 18, wherein the list includes a primary table and a secondary table, the primary table tracking a group allocation and the secondary table mapping virtual uses.

ABSTRACT OF THE DISCLOSURE

An architecture and method for dynamic resource allocation and scheduling in a communication device is disclosed herein. The method of controlling hardware resources in a communication device having a processor, a computer readable memory, and at least one
5 hardware resource coupled to each other includes several steps. The first step locates a memory address in the computer readable memory that is associated with a first hardware resource. In the next step, control information associated with the first memory address is transmitted to the first hardware resource for it to be operated. In the last step, a pointer associated with the first address that locates a subsequent address for a subsequent hardware
10 resource, is read.



IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

DECLARATION FOR PATENT APPLICATION

As a below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below next to my name.

I believe I am an original, first and joint inventor of the subject matter which is described and claimed and for which a patent is sought on the invention entitled:

METHOD AND APPARATUS FOR SOFTWARE-BASED ALLOCATION AND SCHEDULING OF HARDWARE RESOURCES IN AN ELECTRONIC DEVICE

the specification of which was filed on December 30, 2003 as Application No. 10/750,532.

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by an amendment, if any, specifically referred to herein. I do not know and do not believe that the same was ever known or used in the United States of America before my or our invention thereof or patented or described in any printed publication in any country before my or our invention thereof, or more than one year prior to this application, or in public use or on sale in the United States of America more than one year prior to this application, that the invention has not been patented or made the subject of an inventor's certificate issued before the date of this application in any country foreign to the United States of America on an application filed by me or my legal representatives or assigned more than twelve months prior to this application.

I acknowledge the duty to disclose all information known to me that is material to patentability in accordance with Title 37, Code of Federal Regulations, § 1.56.

FOREIGN PRIORITY CLAIM

I hereby claim foreign priority benefits under Title 35, United States Code § 119(a)-(d) of any foreign application(s) for patent or inventor's certificate listed below and have also identified below any foreign application for patent or inventor's certificate having a filing date before that of the application on which priority is claimed:

☒ no such foreign applications have been filed

☐ such foreign application have been filed as follows:

**EARLIEST FOREIGN APPLICATION(S), IF ANY FILED WITHIN 12 MONTHS
(6 MONTHS FOR DESIGN) PRIOR TO THIS U.S. APPLICATION**

Application Number	Country	Date of Filing	Priority Claimed Under 35 USC 119
			___ Yes No ___
			___ Yes No ___
			___ Yes No ___

**ALL FOREIGN APPLICATION(S), IF ANY FILED MORE THAN 12 MONTHS
(6 MONTHS FOR DESIGN) PRIOR TO THIS U.S. APPLICATION**

Application Number	Country	Date of Filing

CLAIM FOR BENEFIT OF EARLIER U.S. PROVISIONAL APPLICATIONS

I hereby claim priority benefits under Title 35, United States Code §119(e), of any United States provisional patent application(s) listed below:

☐ no such U.S. provisional applications have been filed.

☒ such U.S. provisional application have been filed as follows:

Application Number	Date of Filing	Priority Claimed Under 35 USC 119
60/222,853	August 3, 2000	___ Yes No <u>x</u>
		___ Yes No ___
		___ Yes No ___

CLAIM FOR BENEFIT OF EARLIER U.S./PCT APPLICATION(S)

I hereby claim the benefit under Title 35, United States Code, §120 of the United States application(s) listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States application in the manner provided by the first paragraph of Title 35, United States Code, §112, I acknowledge the duty to disclose all information that is material to patentability in accordance with Title 37, Code of Federal Regulations, §1.56 which became available to me between the filing date of the prior application and the national or PCT international filing date of this application:

☐ no such U.S./PCT applications have been filed.

☒ such U.S./PCT application have been filed as follows:

Application Number	Date of Filing	Status (Patented/Pending/Abandoned)
09/922,484	August 3, 2001	

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

I hereby appoint the practitioners under Customer Number

38881

jointly, and each of them severally, my attorneys at law/patent agent(s), with full power of substitution, delegation and revocation, to prosecute this application, to make alterations and amendments therein, to receive the patent, and to transact all business in the U. S. Patent and Trademark Office connected therewith.

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I, David M. Holmes, a citizen of US, residing at 21696 Noonan Court; Cupertino, California 95014;

and each of us, if more than one person is identified above (hereinafter "ASSIGNOR") in consideration of the sum of Ten Dollars (\$10.00), or the equivalent thereof, and other good and valuable consideration, the sufficiency of which and receipt of which are hereby acknowledged, paid to ASSIGNOR by

Infineon Technologies AG

a Corporation organized under the laws of Germany, located at St.-Martin-Strasse 53, 81669 Munich, GERMANY (hereinafter "ASSIGNEE"), do hereby sell and assign to said ASSIGNEE, its successors and assigns, the below indicated right, title, and interest, **in and for the United States of America only** in and to my Invention entitled:

**METHOD AND APPARATUS FOR SOFTWARE-BASED ALLOCATION AND
SCHEDULING OF HARDWARE RESOURCES IN AN ELECTRONIC DEVICE**

invented by me and described in Patent Application No. 10/750,532, filed on December 30, 2003, in the United States; and all patents, divisions, reissues, continuations and any extensions thereof and rights of priority therein, said interest being my entire ownership interest in the same, to be held and enjoyed by said ASSIGNEE, its successors, assigns, or other legal representatives, to the full end of the term thereof, as fully and entirely as the same would have been held and enjoyed by me if this assignment and sale had not be made;

And for the consideration aforesaid, I hereby covenant and agree to and with said ASSIGNEE, its successors and assigns, that whenever ASSIGNEE, its counsel or representative, or the counsel or representative of its successors or assigns, shall advise that an amendment to, or a division of, or any other proceeding or action in connection with an application concerning said Invention, including interference proceedings, is lawful and desirable, or that a reissue or continuation or extension of such application or patent issuing therefrom is lawful and desirable, I will sign all papers and drawings, take all rightful oaths and affidavits, and do all acts necessary or required to be done for the procurement of all lawful rights associated with the Invention, or for the reissue or continuation or extension of the same, will do all acts necessary or required to secure in said ASSIGNEE, its successors or assigns, the title to and full benefit of all rights hereby assigned, without charge to said ASSIGNEE or its successors or assigns, but at its or their expense; and I hereby appoint every present or future officer of said ASSIGNEE as my agent to sign all such papers and to do all such necessary acts on my behalf, to the fullest extent permitted by law;

And I hereby authorize and request the Commission of Patents and Trademarks and any other granting authority to issue any Letters Patent resulting from said Invention and application(s) concerning same to said ASSIGNEE.

This assignment shall have an effective date corresponding to the last date of execution.

I declare under penalty of perjury under the laws of the United States of America, and under penalty of the laws of any other jurisdiction before which this document may be presented, that I have signed this document as my own free act and that all of the foregoing is true and correct.

Dated: _____

Chakki Kavoori, Inventor

Dated: _____

Keith Reiken, Inventor

Dated: _____

David M. Holmes, Inventor

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June 19, 2004

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Re: U.S. Patent Application Serial No. 10/750,532
For: METHOD AND APPARATUS FOR SOFTWARE-BASED
ALLOCATION AND SCHEDULING OF HARDWARE RESOURCES IN
AN ELECTRONIC DEVICE
Filed: December 30, 2003
Your Ref.: 2003P93061 US02

Dear Mr. Holmes:

In accordance with instructions received from Infineon Technologies North America Corp. we enclose new Combined Declaration/Power of Attorney and Assignment documents for execution.

Please review the enclosed Declaration and Assignment documents carefully and sign where indicated. If minor changes need to be made to correct for, *e.g.*, typographical errors, they can be made in pen. However, all such changes must be *initialed and dated*.

Please make sure that you have read the application (forwarded to you on May 4, 2004), including its claims, before you sign any of the documents. Please contact us if you identify any corrections that need to be made in the application.

Please return the executed documents to us for filing with the Patent and Trademark Office before the deadline of **July 5, 2004**. If you have any questions or comments, please do not hesitate to contact me.

Sincerely,

Flynn Barrison

FB:ih

cc: Laura C. Brutman, Esq.

**DECLARATION FOR PATENT APPLICATION, POWER OF
ATTORNEY & DESIGNATION OF CORRESPONDENCE ADDRESS**

As below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below next to my name.

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled:

**METHOD AND APPARATUS FOR SOFTWARE-BASED ALLOCATION AND SCHEDULING
OF HARDWARE RESOURCES IN AN ELECTRONIC DEVICE**

the specification of which (check one)

_____ is attached hereto.

☒ was filed on December 30, 2003 as Application Serial No.
10/750,532

and was amended on _____ (if applicable).

I hereby state that I have reviewed and understand the contents of the above-identified specification including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose information known to me to be material to the patentability of this application in accordance with 37 CFR §1.56(a).

**PRIOR FOREIGN/PCT APPLICATION(S) FILED WITHIN 12 MONTHS (6 MONTHS FOR
DESIGN) PRIOR TO THIS APPLICATION AND ANY PRIORITY CLAIMS UNDER 35
U.S.C. § 119(a)-(d)**

I hereby claim foreign priority benefits under 35 USC § 119 of any foreign application(s) for patent or inventor's certificate listed below and have also identified below any foreign application for patent or inventor's certificate having a filing date before that of the application on which priority is claimed:

Prior Foreign Application(s)			Priority Claimed	
Number	Country	Day/Month/Year Filed	Yes	No

**CLAIM FOR BENEFIT OF PRIOR U.S. PROVISIONAL APPLICATION(S)
(35 U.S.C. § 119(e))**

I hereby claim the benefit under Title 35, United States Code, § 119 (e) of any United States provisional application(s) listed below:

Provisional Application Number	Filing Date
60/222,853	August 3, 2000

**CLAIM FOR BENEFIT OF EARLIER US/PCT APPLICATION(S)
UNDER 35 U.S.C. § 120**

I hereby claim the benefits under 35 USC § 120 of any United States application(s) listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States application in the manner provided by the first paragraph of 35 USC § 112, I acknowledge the duty to disclose material information as defined in 37 CFR § 1.56 which occurred between the filing date of the prior application and the national or PCT international filing date of this application:

Appl. No.	Filing Date	Patented, Pending, Abandoned
09/922,484	August 3, 2001	

Power of Attorney: As a named inventor, I hereby appoint the following attorney(s) and/or agent(s) to prosecute this application and transact all business in the Patent and Trademark Office connected therewith.

Erik O. Berger (Reg. No. 42,315), Stanton C. Braden (Reg. No. 32,556), Marie-Claire B. Maple (Reg. No. 37,588), Gordon D. Coplein (Reg. No. 19,165), Bert J. Lewen (Reg. No. 19,407), Marc S. Gross (Reg. No. 19,614), Michael J. Sweedler (Reg. No. 19,937), Paul Fields (Reg. No. 20,298), S. Peter Ludwig (Reg. No. 25,351), Melvin C. Garner (Reg. No. 26,272), Joseph B. Lerch (Reg. No. 26,936), Adda C. Gogoris (Reg. No. 29,714), Robert C. Sullivan, Jr. (Reg. No. 30,499), Robert Schaffer (Reg. No. 31,194), Peter C. Schechter (Reg. No. 31,662), Joseph R. Robinson (Reg. No. 33,448), Chris Kolefas (Reg. No. 35,226), Pierre R. Yanney (Reg. No. 35,418), David Leason (Reg. No. 36,195), Laura C. Brutman (Reg. No. 38,395), and Scott G. Lindvall (Reg. No. 40,325)

Send correspondence to:

Laura C. Brutman, Esq.
Darby & Darby PC
P.O. BOX 5257
New York, NY 10150-5257

Direct telephone calls to:
212-527-7664

I hereby declare that all statements made herein on my own knowledge are true and that all statements made on information and belief are believed to be true, and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both under

18 USC §1001 and that such willful false statements may jeopardize the validity of the application or any patent issuing thereon.

Full Name of First Inventor: Chakki Kavoori	
Inventor's Signature:	Date:
Residence: San Jose, California	
Citizenship: India	
Mailing Address: 3277 Carol Leaf Court	
San Jose, California 95148	

Full Name of Second Inventor: Keith Reiken	
Inventor's Signature:	Date:
Residence: Cupertino, California	
Citizenship: U.S.A.	
Mailing Address: 21603 La Playa Court	
Cupertino, California 95014	

Full Name of Third Inventor: David M. Holmes	
Inventor's Signature:	Date:
Residence: Cupertino, California	
Citizenship: U.S.A.	
Mailing Address: 21696 Noonan Court	
Cupertino, California 95014	

ASSIGNMENT

For good and valuable consideration, Chakki Kavoori, a citizen of India, residing at 3277 Carol Leaf Court, San Jose, California 95148, Keith Reiken, a citizen of the United States of America, residing at 21603 La Playa Court, Cupertino, California 95014, and David M. Holmes, a citizen of the United States of America, residing at 21696 Noonan Court, Cupertino, California 95014, hereinafter individually or collectively referred to as "Assignor";

Hereby sell, assign and transfer to **Infineon Technologies MorphICs, Inc.**, a corporation organized and existing under the state laws of Delaware, having its principal place of business at 1730 North First Street, San Jose, CA 95112, hereinafter "Assignee", its successors, assigns and legal representatives, the entire right, title and interest in and for the United States and all foreign countries, in and to any and all improvements which are disclosed in the application for United States Letters Patent, which has been executed by the undersigned and filed herewith, entitled:

METHOD AND APPARATUS FOR SOFTWARE-BASED ALLOCATION AND SCHEDULING OF HARDWARE RESOURCES IN AN ELECTRONIC DEVICE

and in and to said application and all divisional, continuing, substitute, renewal, reissue, and all other applications for Letters Patent which have been or shall be filed in the United States and all foreign countries on any of said improvements; and in and to all original and reissued patents which have been or shall be filed in the United States and all foreign countries on said improvements;

Agree that said Assignee may apply for and receive Letters Patent for said improvements in its own name; and that, when requested, without charge to but at the expense of said Assignee, its successors, assigns and legal representatives, to carry out in good faith the intent and purpose of this assignment, the undersigned will execute all divisional, continuing, substitute, renewal, reissue, and all other patent applications on any and all said improvements; execute all rightful oaths, assignments, powers of attorney and other papers; communicate to said Assignee, its successors, assigns, and legal representatives, all facts known to the undersigned relating to said improvements and the history thereof; and generally do everything possible which said Assignee, its successors, assigns or legal representatives shall consider desirable for aiding in securing and maintaining proper patent protection for said improvements and for vesting title to said improvements and all applications for patents and all patents on said improvements, in said Assignee, its successors, assigns and legal representatives; and

Covenant with said Assignee, its successors, assigns and legal representatives that no assignment, grant, mortgage, license or other agreement affecting the rights and property herein conveyed has been made to others by the undersigned, and that full right to convey the same as herein expressed is possessed by the undersigned.

SIGNATURE: _____ DATE: _____
NAME: Chakki Kavoori

SIGNATURE: _____ DATE: _____
NAME: Keith Reiken

SIGNATURE: _____ DATE: _____
NAME: David M. Holmes

DARBY &
DARBY

PROFESSIONAL
CORPORATION



FLYNN BARRISON

ASSISTANT PATENT SERVICES MANAGER

212-527-7748

fbarrison@darbylaw.com

INTELLECTUAL PROPERTY LAW

NEW YORK

805 THIRD AVENUE

NEW YORK, NY 10022-7513

TEL 212.527.7700

FAX 212.753.6237

SEATTLE

1191 SECOND AVENUE

SEATTLE, WA 98101

TEL 206.262.8900

FAX 206.262.8901

Reference: 04303/100N160-US2

David M. Holmes
21696 Noonan Court
Cupertino, CA 95014

Re: U.S. Patent Application Serial No. 10/750,532
For: METHOD AND APPARATUS FOR SOFTWARE-BASED
ALLOCATION AND SCHEDULING OF HARDWARE RESOURCES IN
AN ELECTRONIC DEVICE
Filed: December 30, 2003
Your Ref.: 2003P93061 US02

Dear Mr. Holmes:

Further to our letter dated June 11, 2004, we enclose a new Combined Declaration and Power of Attorney document for execution. Unfortunately, the Combined Declaration/Power of Attorney we originally provided to you is no longer acceptable with the United States Patent Office. The United States Patent Office has recently amended the rule for the requirements of a Power of Attorney. Effective June 25, 2004, all Power of Attorney documents must either list a Customer Number or no more than ten attorneys. Since the Power of Attorney we provided you listed more than ten attorneys, we were unable to submit it to the Patent Office.

Please return the executed documents to us for filing with the Patent and Trademark Office before the extendible deadline of **August 5, 2004**. If you have any questions or comments, please do not hesitate to contact me.

Sincerely,

Flynn Barrison

FB:ih

cc: Laura C. Brutman, Esq.

**DECLARATION FOR PATENT APPLICATION, POWER OF
ATTORNEY & DESIGNATION OF CORRESPONDENCE ADDRESS**

As below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below next to my name.

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled:

**METHOD AND APPARATUS FOR SOFTWARE-BASED ALLOCATION AND SCHEDULING
OF HARDWARE RESOURCES IN AN ELECTRONIC DEVICE**

the specification of which (check one)

_____ is attached hereto.

☒ _____ was filed on December 30, 2003 as Application Serial No.
10/750,532

and was amended on _____ (if applicable).

I hereby state that I have reviewed and understand the contents of the above-identified specification including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose information known to me to be material to the patentability of this application in accordance with 37 CFR §1.56(a).

**PRIOR FOREIGN/PCT APPLICATION(S) FILED WITHIN 12 MONTHS (6 MONTHS FOR
DESIGN) PRIOR TO THIS APPLICATION AND ANY PRIORITY CLAIMS UNDER 35
U.S.C. § 119(a)-(d)**

I hereby claim foreign priority benefits under 35 USC § 119 of any foreign application(s) for patent or inventor's certificate listed below and have also identified below any foreign application for patent or inventor's certificate having a filing date before that of the application on which priority is claimed:

Prior Foreign Application(s)			Priority Claimed	
Number	Country	Day/Month/Year Filed	Yes	No

**CLAIM FOR BENEFIT OF PRIOR U.S. PROVISIONAL APPLICATION(S)
(35 U.S.C. § 119(e))**

I hereby claim the benefit under Title 35, United States Code, § 119 (e) of any United States provisional application(s) listed below:

Provisional Application Number	Filing Date
60/222,853	August 3, 2000

**CLAIM FOR BENEFIT OF EARLIER US/PCT APPLICATION(S)
UNDER 35 U.S.C. § 120**

I hereby claim the benefits under 35 USC § 120 of any United States application(s) listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States application in the manner provided by the first paragraph of 35 USC § 112, I acknowledge the duty to disclose material information as defined in 37 CFR § 1.56 which occurred between the filing date of the prior application and the national or PCT international filing date of this application:

Appl. No.	Filing Date	Patented, Pending, Abandoned
09/922,484	August 3, 2001	

Power of Attorney: As a named inventor, I hereby appoint the practitioners under Customer Number

38881

jointly, and each of them severally, my attorneys at law/patent agent(s), with full power of substitution, delegation and revocation, to prosecute this application, to make alterations and amendments therein, to receive the patent, and to transact all business in the U.S. Patent and Trademark Office connected therewith.

Send correspondence to:

Laura C. Brutman, Esq.
Darby & Darby PC
P.O. BOX 5257
New York, NY 10150-5257

Direct telephone calls to:
212-527-7664

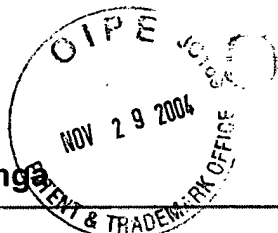
I hereby declare that all statements made herein on my own knowledge are true and that all statements made on information and belief are believed to be true, and

further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both under 18 USC §1001 and that such willful false statements may jeopardize the validity of the application or any patent issuing thereon.

Full Name of First Inventor: Chakki Kavoori	
Inventor's Signature:	Date:
Residence: San Jose, California	
Citizenship: India	
Mailing Address: 3277 Carol Leaf Court	
San Jose, California 95148	

Full Name of Second Inventor: Keith Reiken	
Inventor's Signature:	Date:
Residence: Cupertino, California	
Citizenship: U.S.A.	
Mailing Address: 21603 La Playa Court	
Cupertino, California 95014	

Full Name of Third Inventor: David M. Holmes	
Inventor's Signature:	Date:
Residence: Cupertino, California	
Citizenship: U.S.A.	
Mailing Address: 21696 Noonan Court	
Cupertino, California 95014	



Hildreth, Inga

From: Heather.Rowland@infineon.com
Sent: Tuesday, November 02, 2004 3:48 PM
To: Hildreth, Inga
Cc: Brutman, Laura
Subject: RE: METHOD AND APPARATUS FOR SOFTWARE-BASED ALLOCATION AND SCHEDULING OF HARDWARE RESOURCES IN AN ELECTRONIC DEVICE - Your Ref.: 2003P93061 US02 - Our Ref.: 04303/100N160-US2

Hi Inga,

I sent Mr. Holmes an e-mail requesting his home address and he stated that he is not willing to take the time to read the application or sign any documents. Therefore, please do not send the documents to him for signature. Please file the necessary documents with the Patent Office regarding the absence of Mr. Holmes's signature from the Declaration.

Please let me know if you have any questions.

Regards,
 Heather

Heather Rowland, CP
 Patent Administrator
 IFNA IC
 Infineon Technologies North America Corp.
 3000 CentreGreen Way
 Cary, NC 27513

+1 919 677 3024 (phone)
 +1 919 678 1899 (fax)

-----Original Message-----

From: Hildreth, Inga [mailto:ihildreth@Darbylaw.com]
Sent: Tuesday, November 02, 2004 3:10 PM
To: Rowland Heather (IFNA IC)
Subject: RE: METHOD AND APPARATUS FOR SOFTWARE-BASED ALLOCATION AND SCHEDULING OF HARDWARE RESOURCES IN AN ELECTRONIC DEVICE - Your Ref.: 2003P93061 US02 - Our Ref.: 04303/100N160-US2

Heather,

I have his home address as 21696 Noonan Court in California. I am sending the Federal Express Package to that address.

Inga Hildreth
 Patent Paralegal
 Darby & Darby P.C.
 805 Third Avenue
 New York, NY 10022

11/2/2004

917.286.2905 | direct
212.753.6237 | fax

<http://www.darbylaw.com>

CONFIDENTIALITY NOTICE. This email message and any attachments may be confidential and may be subject to the attorney-client privilege or other privilege. If you are not the intended recipient, please do not read, copy or re-send this email message or its attachments; immediately notify the sender by reply email or by collect call to 212.527.7700 or 206.262.8900; and delete this email message and any attachments. Thank you for your assistance.

-----Original Message-----

From: Heather.Rowland@infineon.com [mailto:Heather.Rowland@infineon.com]

Sent: Tuesday, November 02, 2004 3:08 PM

To: Hildreth, Inga

Cc: Brutman, Laura

Subject: RE: METHOD AND APPARATUS FOR SOFTWARE-BASED ALLOCATION AND SCHEDULING OF HARDWARE RESOURCES IN AN ELECTRONIC DEVICE - Your Ref.: 2003P93061 US02 - Our Ref.: 04303/100N160-US2

Hi Inga,

Below is an e-mail address David Holmes gave when he left Infineon Technologies. If this doesn't work, let me know and I will try to get a home address.

dholmes@221bbakerstreet.us

Regards,
Heather

Heather Rowland, CP
Patent Administrator
IFNA IC
Infineon Technologies North America Corp.
3000 CentreGreen Way
Cary, NC 27513

+1 919 677 3024 (phone)
+1 919 678 1899 (fax)

-----Original Message-----

From: Hildreth, Inga [mailto:ihildreth@Darbylaw.com]

Sent: Tuesday, November 02, 2004 2:12 PM

To: Rowland Heather (IFNA IC)

Cc: Brutman, Laura

Subject: RE: METHOD AND APPARATUS FOR SOFTWARE-BASED ALLOCATION AND SCHEDULING OF HARDWARE RESOURCES IN AN ELECTRONIC DEVICE - Your Ref.: 2003P93061 US02 - Our Ref.: 04303/100N160-US2

Hi Heather:

We have received executed documents from two inventors, Mr. Kavoori and Mr. Reiken. Unfortunately, the documents they provided had changes. We are forwarding new documents to these two inventors by Federal Express today.

Mr. Holmes has not returned any documents.

Inga Hildreth
Patent Paralegal
Darby & Darby P.C.
805 Third Avenue
New York, NY 10022

917.286.2905 | direct
212.753.6237 | fax

<http://www.darbylaw.com>

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-----Original Message-----

From: Heather.Rowland@infineon.com [mailto:Heather.Rowland@infineon.com]
Sent: Tuesday, November 02, 2004 1:20 PM
To: Hildreth, Inga
Subject: RE: METHOD AND APPARATUS FOR SOFTWARE-BASED ALLOCATION AND SCHEDULING OF HARDWARE RESOURCES IN AN ELECTRONIC DEVICE - Your Ref.: 2003P93061 US02 - Our Ref.: 04303/100N160-US2

Hi Inga,

Did you ever receive the executed documents from the inventors?

Thanks,
Heather

Heather Rowland, CP
Patent Administrator
IFNA IC
Infineon Technologies North America Corp.
3000 CentreGreen Way
Cary, NC 27513

+1 919 677 3024 (phone)
+1 919 678 1899 (fax)

-----Original Message-----

From: Hildreth, Inga [mailto:ihildreth@Darbylaw.com]
Sent: Thursday, September 30, 2004 1:14 PM
To: Voelker Gudrun (IFNA IC)
Cc: Brutman, Laura
Subject: FW: METHOD AND APPARATUS FOR SOFTWARE-BASED ALLOCATION AND SCHEDULING OF HARDWARE RESOURCES IN AN ELECTRONIC DEVICE - Your Ref.: 2003P93061 US02 - Our Ref.:

04303/100N160-US2

Hi Gudrun:

Further to my email of August 10, 2004, I am still waiting for the executed declaration/power of attorney and assignment documents from Mr. David Holmes. Additionally, I have received an executed declaration/power of attorney (as per the attached declaration/poa) executed by Mr. Reiken. However, Mr. Reiken executed the documents and changed his address but never initialed the changes, which is required by the US Patent and Trademark Office. As for Mr. Kavoori, I still have not received the newly executed declaration/power of attorney.

I need to return Mr. Reikens documents to him, but if you have an email address for the inventors I will be more than happy to contact the inventors myself.

Please note, we are now into the third month extension. The third month expires on October 5, 2004.

Thank you

Inga Hildreth
Patent Paralegal
Darby & Darby P.C.
805 Third Avenue
New York, NY 10022

917.286.2905 | direct
212.753.6237 | fax

<http://www.darbylaw.com>

CONFIDENTIALITY NOTICE. This email message and any attachments may be confidential and may be subject to the attorney-client privilege or other privilege. If you are not the intended recipient, please do not read, copy or re-send this email message or its attachments; immediately notify the sender by reply email or by collect call to 212.527.7700 or 206.262.8900; and delete this email message and any attachments. Thank you for your assistance.

-----Original Message-----

From: Hildreth, Inga
Sent: Tuesday, August 10, 2004 1:43 PM
To: 'Gudrun.Voelker@infineon.com'
Subject: METHOD AND APPARATUS FOR SOFTWARE-BASED ALLOCATION AND SCHEDULING OF HARDWARE RESOURCES IN AN ELECTRONIC DEVICE - Your Ref.: 2003P93061 US02 - Our Ref.: 04303/100N160-US2

Hi Gudrun:

The above-identified subject matter pertains to a Response to the Notice

11/2/2004

of Missing Parts of Application which was due on July 5, 2004 without an extension. I have sent the attached letters and formal documents to the inventors, but have not received any executed documents in return.

The Response to Missing Parts can be filed with extensions up to five months, however these fees are escalating. I have sent out a copy of the letter with a reminder note to the inventors. Can you please assist me with this matter. The next due date is **September 5th** with a two month extension.

Thank you,

Inga Hildreth
Patent Paralegal
Darby & Darby P.C.
805 Third Avenue
New York, NY 10022

917.286.2905 | direct
212.753.6237 | fax

<http://www.darbylaw.com>

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